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OBITUARY

William Jerome Hancock died at his home in New York City on Sept. 18, 1926. He was born at Albion, Maine. After receiving the degrees of Bachelor of Science and Master of Science from the University of Maine, he taught for some years in his native state; later he became professor of chemistry at Antioch College, Ohio, where he remained for eight years. Subsequently he went to Brooklyn, N. Y., as a teacher of chemistry in Erasmus Hall High School. At the time of his death he was head of the science department.

Mr. Hancock was a past president of the Chemistry Teachers' Club of New York, a member of the American Association for the Advancement of Science, chairman of the N. Y. State Regents examination committee for chemistry, and vice-president of the Science Section of the Association of Schools and Colleges of the Middle States and Maryland. He was a joint author of the text-books "The Elementary Principles of Chemistry" and "The Chemistry of Common Things."

His wife, Caroline Ellis of Yellow Springs, Ohio, survives him.

UNITED STATES CIVIL-SERVICE EXAMINATION FOR UNDER SCIENTIFIC HELPER

Applications for under scientific helper must be on file at Washington, D. C., not later than November 27th. The date for assembling of competitors will be stated on the admission cards sent applicants after the close of receipt of applications, and will be about ten days after that date.

The examination is to fill vacancies in the Departmental Service, Washington, D. C., and in positions requiring similar qualifications.

The entrance salary is $1140 a year. After the probational period required by the civil-service act and rules, advancement in pay without material change in duties may be made to higher rates within the pay range for the grade, up to a maximum of $1500 a year. Promotion to higher grades may be made in accordance with the civil-service rules as vacancies occur.

The general duties of the position will be to perform, under immediate supervision, elementary laboratory, museum, observatory, or field work requiring a small amount of training or experience in biological, physical, or mathematical sciences.

Examination will be given in the optional subjects of physics and chemistry, or elementary biology and laboratory technic.

Competitors will be rated on practical questions on the optional subject selected, and on their education, training, and experience.

Full information and application blanks may be obtained from the United States Civil Service Commission, Washington, D. C., or the secretary of the board of U. S. civil-service examiners at the post office or custom house in any city.

Grass Cloth May Rival Cotton Goods. The secret of turning tropical grasses and other fibrous substances into clothes to wear is believed to have been solved by Dr. Dinshaw Nanji of Birmingham University. Chemical processes are said to have been perfected for separating the fibers from the raw materials and preparing them for spinning. The fabrics, if commercially successful, may take the place of cotton in the regions where large supplies of grasses are available. It is thought that new and interesting materials may be developed for wearing apparel and for other uses.—*Science Service*

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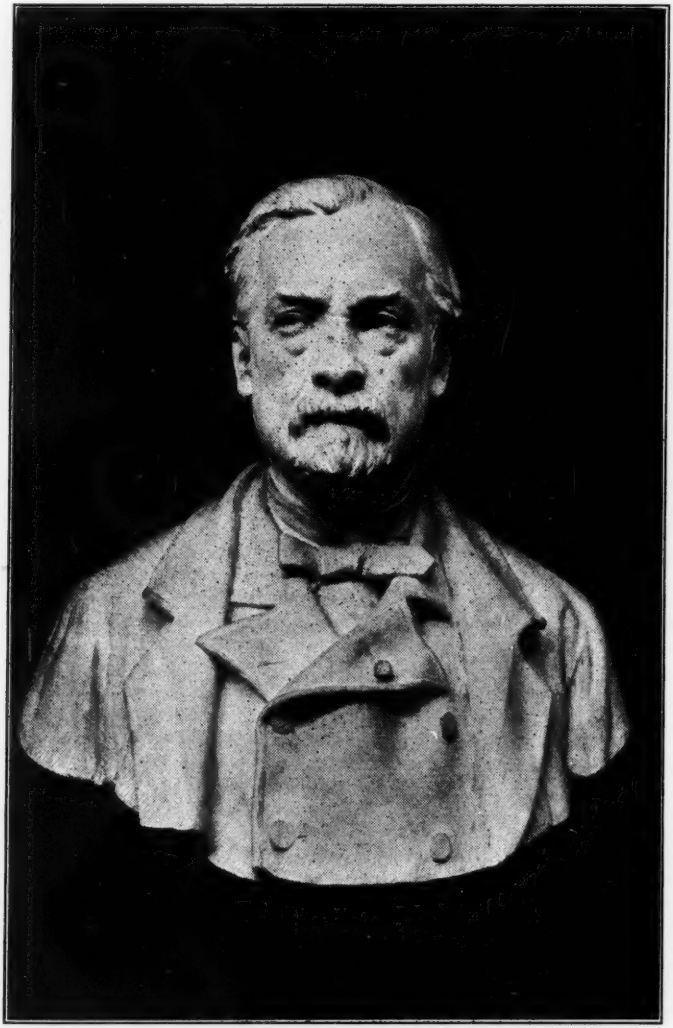


BUST OF PASTEUR BY PAUL DUBOIS

EDITOR'S OUTLOOK

Mental Catalysis

CONSIDERABLE attention has been directed of late toward devising means of making chemistry more interesting to students. This applies chiefly to high-school and freshman students and more particularly to those who do not expect to employ their knowledge of chemistry professionally.

Although some individuals continue to cling to the stern disciplinary theory that that which is distasteful must, therefore, be salutary also, the majority of us have been converted to a different view. Most of us are ready to concede that while suffering may under certain circumstances ennoble, the evasion of unnecessary pain does not inevitably imply moral turpitude. Granted this, the question resolves itself into "what to do?"

There has been no lack of suggestions. In fact, as Dr. Keach intimates in a recent article,[1] it is time that we critically examine some of our enthusiasms lest they lead us astray.

At the outset let us make a point which is, we hope, usually taken for granted, yet which may, because never mentioned, be overlooked. Interest must be transmitted, rather than created out of thin air through some species of psychological prestidigitation. True, our advertising wizards and our high-pressure salesmen modestly admit that they can build up enthusiasm for the product of any manufacturer who can guarantee the payment of their accounts. Even these gentlemen have been known to state confidentially, however, that they turn out a better job when they have actual confidence in the product they exploit. Theoretically, of course, every teacher of chemistry is vitally interested in his work, but—we sometimes wonder.

It may seem irrelevant to remark that the personality of the teacher will play an important part in any transmission of interest, yet we believe that this is an essential fact, too little emphasized. Interest is contagious only under certain favorable conditions. We do not readily espouse the enthusiasms of those whom we dislike or hold in light esteem. The teacher who antagonizes his class creates (illogically enough, but nevertheless surely) a dislike for his subject as well as for himself. The teacher who has any of the ear-marks of the pedant or of the monomaniac will find his enthusiasms discounted in advance. His class will at once assume that he thrives on dry and dusty mental fare and will expect to find whatever interests him dull and uninspiring.

Some teachers will, no doubt, resent the implication that the cultivation of good-will is any part of their obligation. Perhaps the instructors of future chemists or of others who will need chemistry in their later work can afford to assume a public-be-damned attitude and rely upon necessity

[1] THIS JOURNAL, 3, 556–9 (May, 1926).

to drive their students. The instructor in cultural chemistry had as well admit first as last, however, that his calling, like that of the actor or the politician, depends for success upon a certain measure of personal popularity, entirely aside from the intrinsic merit of his work. If this admission is beneath his dignity he had better seek other employment.

We do not take the discouraging view that popularity is one of those gifts which one has or one hasn't and that there is nothing to be done about it. Nevertheless, a word of caution to the effect that weak-spined and ill-advised attempts to curry favor are quickly diagnosed and held in contempt by the students.

With these facts in mind, it is well to note also that making a course interesting is not synonymous with making it easy. That which is interesting seems easy but the converse does not follow. This is not to say that unnecessary difficulties should not be eliminated, but they should be eliminated because they are unnecessary rather than because they are difficult. No one will contend that the candidate for the football team has an easy time, yet no one can doubt his interest. The elimination of difficulties is not, then, the magic formula.

What are the sources of interest? We may well differentiate here between direct, or intrinsic, and secondary interests. By the former we mean interest in the subject for itself alone; by the latter, interest in the subject as a means toward an end. The instructor may legitimately appeal to both.

The main factor in direct interest is probably natural curiosity as to the workings of the universe. By the time the student reaches high-school or university age his original curiosity has been partly satisfied and partly discouraged. It is often dormant. If so, the instructor must arouse it. Thus one of the most effective ways of presenting new material is in the form of an answer to a question previously raised.

True, the ordinary text-book or course outline in general chemistry includes information which cannot reasonably be construed as answering any question that would ever occur to a freshman or that would, if suggested to him, arouse his curiosity. These are subjects for critical examination. If it be decided that they are essential, then the instructor must adopt the tactics of the detective-story writer. He must suggest a problem which will include the points he wishes to make. He must then indicate the information and procedures which are necessary for its solution and proceed to teach them on the strength of the suspended interest in his problem.

Undoubtedly there will be times when this system cannot be applied. At best it is far from a fool-proof formula. Many teachers will never be able to apply it with any degree of success. No doubt, too, it will, even in expert hands, leave some students untouched. However, these considerations are equally applicable to any scheme which may be advanced.

Newspaper men inform us that personalities are an unfailing source of interest. This is a hint which may be kept in mind by the advocates of the historical method of approach. The mere attachment of names and dates to chemical facts does not create interest. If chemical celebrities cannot be introduced as living, breathing human beings they had best be left undisturbed. Nor should these historical characters be "dragged in by the heels." In the general chemistry course, biographical and historical material must remain contributory to the central theme. Irrelevancies, however intriguing, should be avoided.

Biographical material fits in excellently with the method of attack just described. A general sample outline might proceed somewhat in this manner. Here are certain observed facts, puzzling when viewed from the empirical standpoint. What are the principles which clarify the apparent mystery? This was the problem which confronted Dr. Blank. Here a brief but vivid sketch of Dr. Blank may be appropriately interpolated. He is to constitute the hero of our episode—the Sherlock Holmes of our mystery tale. Like the hero of any other good story, he should be presented in a manner to arouse the sympathy of the hearer and create interest in his proceedings. What did Dr. Blank already know which might prove useful in solving this problem? (The answer will constitute a brief recapitulation of relevant points already touched upon, if the course has been properly planned.) What else did he need to know? How did he set about finding it out? What were his final conclusions? This skeleton is subject to infinite variation and embellishment, depending upon the point under discussion.

Similarly, practical applications are much more effective when introduced through an appropriate preamble and accompanied by a proper background than when pitch-forked into the course. For instance, when the students have been acquainted with such chemical facts as will make the narration intelligible to them, the instructor may digress briefly to present a concise review of the development of an art or industry up to a certain point. What problem confronted it or what obstacle impeded its progress at the point where he pauses in his review? How was this obstacle overcome through an application of the facts just presented? This scheme, also, must be adapted to fit the case in hand. Frequently some consideration of economic principles is appropriate in such a connection.

Passing from intrinsic to secondary interests, we naturally think of the usefulness of the subject to students in after life. How can we impart to them our own conviction that chemistry will later be of service to them? Possibly by pointing out, here and there, facts that are applicable in everyday activities. Probably, however, this objective can be more effectively achieved by the more devious means of propaganda and innuendo. A knowledge of chemistry comes to one's aid in such unpredictable ways.

Not the least of these is that it sometimes guards one against making an ass of himself in public places. Many illustrative anecdotes will occur to any teacher.

There was, for instance, the lawyer involved in a government suit against a feed manufacturer whose product failed to meet its fat and protein guarantees. This gentleman provided considerable amusement at his own expense by dashing over to one of the chemical experts present and inquiring how to calculate percentage of fat from percentage of nitrogen.

Others may remember the series of six lectures in which an eminent evangelist of an earlier day undertook to refute "the infidel, Robert Ingersoll." In one, which dealt with Jonah and the whale, he contended that it would have been quite possible for Jonah, by "moving about," to "prevent the digestive juices taking hold of him."

Such absurdities are trifling things, yet among the enlightened they indelibly stamp a man as ignorant, and react to the detriment of any cause with which he associates himself.

Such motivations as the desire for approval bring us again to the personality of the instructor. The student will value the approval of a teacher only if he respects that teacher. Prizes and contests may increase activity to a certain degree but we believe that they should be regarded as artificial stimulants rather than as sound nourishment for interest.

Finally, the instructor should be an alert opportunist in the matter of relating his course to the rest of the curriculum. We have already discussed that point at some length in these columns.[2] It may be well to add that discretion should prevent carrying the idea to extremes. Strained relationships and far-fetched allusions should be avoided.

We have implied, and desire to reiterate specifically, that there are no absolutely reproducible procedures for stimulating interest. In the final analysis, the matter rests upon intangibles. Such concrete suggestions as have been embodied in this dissertation should be interpreted as illustrations of our theme rather than as directions "how to succeed."

[2] "Revitalizing Education," THIS JOURNAL, 3, 969–72 (Sept., 1926).

CHEMICAL RESEARCH AT THE PASTEUR INSTITUTE

ATHERTON SEIDELL, HYGIENIC LABORATORY, U. S. PUBLIC HEALTH SERVICE, WASHINGTON, D. C.

Introduction

Visitors to the Pasteur Institute of Paris are usually given a small illustrated booklet as a parting souvenir. In this, attention is first drawn to the limited space occupied by Pasteur's first laboratory in the attic of the Normal School as compared with the more than 30,000 square meters occupied by the present Institute. It is pointed out that even this tremendous increase does not embrace all that has developed from the seed sown by Pasteur in the little laboratory of the rue d'Ulm. His work has had a vigor of growth comparable with that of the microbes with which it deals.

The original building of the Pasteur Institute completed in 1888.

At the completion of his successful studies upon rabies, the throngs of patients who came to him soon directed attention to the inadequacy of his quarters. An international public subscription was, therefore, launched, on the initiative of the Academy of Sciences, to provide funds for the establishment of an institute devoted to his work. This effort soon yielded two and one-half million francs. After the purchase of a site and the erection and equipment of the original buildings there remained one million

francs as endowment. The services for which this provided were inaugurated on the 18th of November, 1888, and since that time other donations have greatly supplemented the original foundation.

Naturally, the first service installed was the care of persons wounded by rabid animals. These numbered several thousand annually for many years. The necessary rooms for the preparation of the antirabic material, and the reception and treatment of patients, were set aside and adequately equipped. It was here that Pasteur, partially incapacitated by paralysis,

The Tomb of Pasteur at the Pasteur Institute.

found most pleasure during the latter years of his life. His manner of receiving and comforting these patients and his favorite place for observing their treatment is well remembered by many who are still employed at the Institute. Among these is Joseph Meister who, as a child of nine years, was the first person to receive the antirabic treatment. As concierge, he still occupies, with his wife and children, one of the gate houses of the Institute.

The original building shown in the picture on page 1217 consists of two parallel wings connected by a central passage. The right side of the front wing contains the living quarters occupied by Pasteur until his death in 1895. The left side is devoted mainly to the library. The entire rear wing consists of laboratories.

Since the death of Pasteur the principal rooms of his living quarters have been used as a repository for the apparatus, note-books, and all personal mementos of his research activities. Thus, there are here collected in the very rooms in which he lived those souvenirs most intimately connected with his remarkable discoveries. Furthermore, the body of Pasteur is interred in a beautiful crypt constructed beneath the main entrance to the building. The Pasteur Institute of Paris is, therefore, the true shrine of Pasteur and his work.

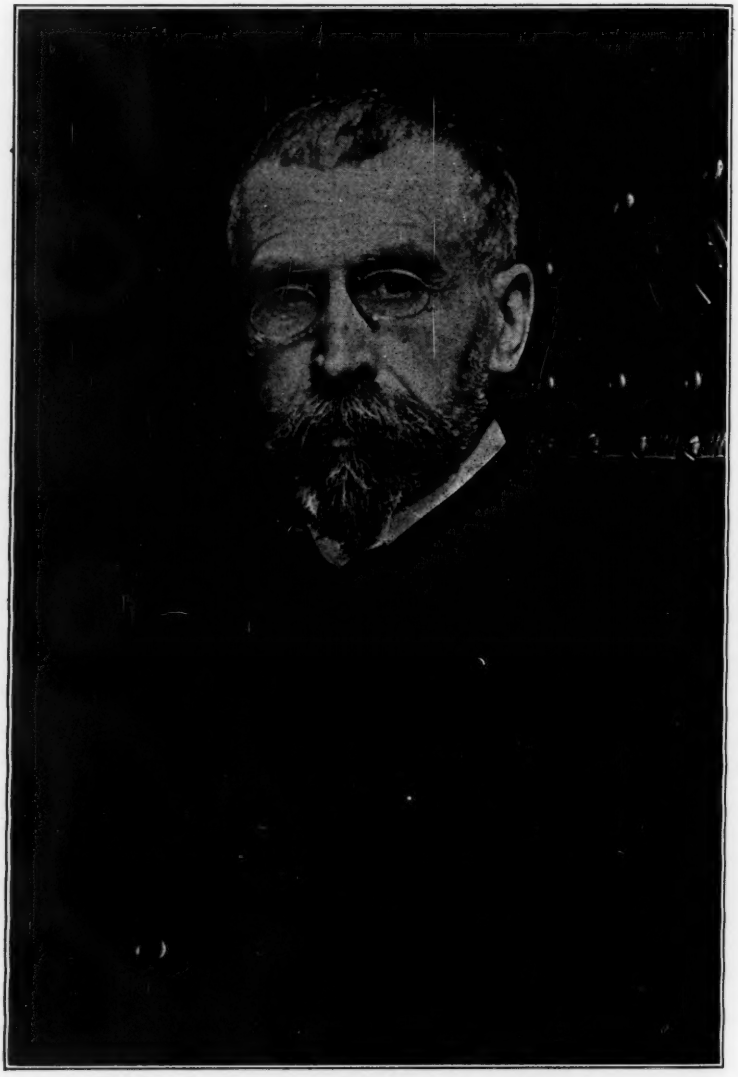
The bust of Pasteur made by Aronson in 1922 to commemorate the 100th anniversary of the birth of Pasteur.

At the time of the founding of the Pasteur Institute, Emile Duclaux who had assisted Pasteur in much of his work and who had been recently appointed to the chair of biological chemistry in the University of Paris (Sorbonne), obtained the authorization of the Minister of Education to transfer his department to the new Institute. This instructional unit, together with the annual course in technical bacteriology inaugurated in 1889, and the practical instruction in fermentation later initiated, as well as the numerous research laboratories, the hospital for infectious diseases and various other services including the productions of serums and antitoxins, have made of the Pasteur Institute an immense college of pure and applied biological science.

Its income is derived from the endowments which have been made from time to time, from small subventions from the State, city of Paris and departments, in return for serums supplied to public hospitals and institutions, from the sale of biological products in France and its colonies, from tuition fees, and finally from miscellaneous donations. A recent example of one of these is a gift received from Princess Marie of Greece, in memory of her father, Prince Roland Bonaparte. This has been used to construct a special monkey house needed in connection with Dr. Calmette's studies on tuberculosis and cancer.

As mentioned in the concluding paragraph of the souvenir booklet given to visitors, the Institute is a product of private initiative, directed and principally sustained by the contributions of devoted and self-sacrificing

workers within, and by generous friends outside the Institute. The internal organization is characterized by a flexibility which permits its doors to be thrown open to serious workers from all countries. Quoting from Dr.



DR. ÉMILE ROUX, DIRECTOR OF THE PASTEUR INSTITUTE SINCE 1904

Roux, the present director, "The importance of each member of the Institute is measured by the service which he renders, and the best title for advancement is the production of good work. We receive anyone who brings an interesting idea and we do not hesitate to give him aid, even if he does not work among us. To continue and develop the work of Pasteur in all the lines which it has opened is the program of the Pasteur Institute."

To even enumerate the thirty-odd research and service divisions of the Pasteur Institute is not contemplated in the present article, but simply to briefly describe those in which chemistry is now playing an important part.

The Laboratory of Biological Chemistry

As previously mentioned, this laboratory has formed an important part of the Pasteur Institute since its earliest days. Its first chief was Emile Duclaux, who occupied the dual position of Professor of Biological Chemistry in the Sorbonne and Chief of the Laboratory of Biological Chemistry of the Pasteur Institute. Since the beginning, all students of the University who pursue work in biological chemistry have come to the Pasteur Institute for their lectures and laboratory work, and the candidates for post-graduate degrees in this subject do their research in the laboratories of the Institute. Of these latter the number usually varies between ten and twenty and they represent almost as many different countries.

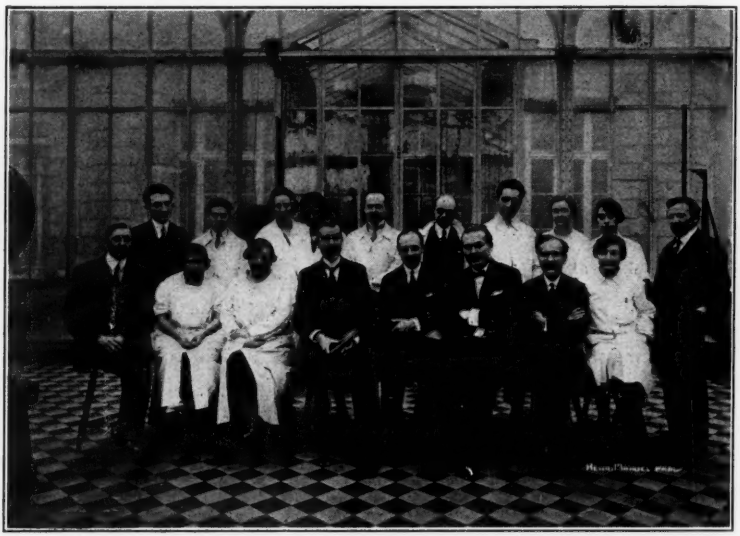
Duclaux directed the work of the division of biological chemistry from its beginning until his death in 1904. He, like Pasteur, was trained as a chemist and studied bacteria from the chemical point of view. His attention was directed particularly to the soluble ferments or enzymes which are secreted by bacteria and by means of which they produce definite reactions.

The successor of Duclaux is Professor Gabriel Bertrand who has also contributed largely to the subject of ferments and, in particular, the diastases and oxydases. His discovery of laccase and of tyrosinase, as well as their composition and mode of action, have been the subject of numerous publications from his laboratory. The presence of manganese in laccase and the role of this metal in plant nutrition early attracted his attention. Its distribution in plant and animal tissues was studied in detail and its action as a catalytic fertilizer was demonstrated.

The conception of the importance of those constituents of living organisms present in infinitesimally small amounts has been developed by M. Bertrand in many directions and has been the guiding principle in much of the research done under his direction.

Pasteur and his associates introduced the expression "infiniment petit" to describe the microörganisms which they studied, and Bertrand modified this term by the addition of the word "chimique" to describe the auxiliary chemical products which played such an important role in enzyme action.

As a result of a very great number of experiments, especially upon laccase, he believes that catalytic transformations of a biological character are not due in each particular case to the intervention of a single substance, possessing a combination of properties which are ordinarily attributed to enzymes, but to a system of several substances. One of these, the active complement, is itself sufficient to produce the chemical transformation, but in the extremely diluted condition in which it is ordinarily present in the living cell, it cannot cause the transformation except at a very slow rate. The other constituent, the *activating complement*, or co-ferment as it was formerly defined, accelerates the action of the *active complement*.



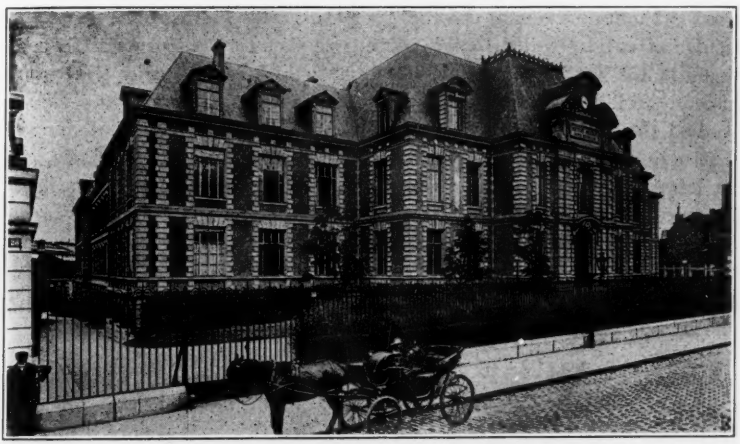
Professor Gabriel Bertrand, Chief of the Biological Chemical Laboratory, and a group of his assistants and students (April, 1926).

In the chemically definite enzymic transformations, which are the only ones that can be studied with precision, the *activating complement* is of a very simple composition. It may be an acid or a salt of alkaline or neutral reaction, and is most frequently of a mineral nature. Its action obeys the ordinary laws of chemistry.

The *active complement* is of a more complex nature and nearly always colloidal. It brings to the system the characters of instability, specificity, etc., which are usually attributed to enzymes. Due to its molecular complexity, it may vary from one living species to another, in respect to its resistance to heat, light, or other agents.

This conception of the mechanism of enzymic action has been supported by evidence obtained in a great variety of subsequent researches. Recently, it has been drawn upon to explain the surprising results showing the influence of nickel and cobalt upon the physiological action of insulin. These experiments were a part of a systematic survey of the distribution and function of various elements in plant and animal organisms.

After showing, with M. Mogokrantz, that both nickel and cobalt are present in all samples of arable soils and, furthermore, that appreciable quantities could be detected in all plants, analyses of the various organs of several higher animals made by M. Macheboef showed that the pancreas



Pasteur Institute—The Biological Chemical Building.

was exceptionally rich in these metals. It was also found that the nickel and cobalt of the pancreas became concentrated in the insulin prepared from this organ. It, therefore, appeared evident that these metals fulfil some special function in the physiological action of the pancreas. Experiments upon depancreatinized dogs and rabbits showed that the action of injected insulin was markedly modified by the simultaneous injection of either cobalt or nickel or both together. Finally, evidence was obtained that the condition of patients suffering from certain types of diabetes was distinctly ameliorated by the salts of these metals. These curious results appear most reasonably explained on the basis that these metals play the rôle of *activating complement* to the insulin molecule which must be considered as the *active complement* in the highly complex system localized in the pancreas.

Although this field of the "infiniment petits chimiques" has been culti-

vated by M. Bertrand and his students over a long period, his attention has also been turned to a number of other important subjects. Among these may be mentioned his studies upon sugars, and especially the preparation of new sugars by the method of selective bacterial action. He was among the earliest to work upon the chemical composition of adrenaline. He made very important contributions to the study of venoms of batrachians and reptiles. In connection with his work upon the distribution of various elements in plants and animals, it became necessary for him to develop analytical methods of greater and greater refinement.

During the war the laboratory of M. Bertrand was called upon for aid in gas warfare problems, and in this connection made important contributions to the production of chloropicrin. In recent years he has given particular attention to developing peace-time uses for this remarkable compound. He has demonstrated its advantages for suffocating silk worms instead of killing them by dry or moist heat as hitherto practiced. He has studied the use of chloropicrin for the fumigation of ships, and for the destruction of vermin and pests in storehouses, libraries, granaries, etc. He has also given attention to the possibility of sterilizing arable soils by its vapors.

The laboratory of M. Bertrand is of an especially international character since students come to him from a great number of countries. Of those at present working under his direction, some of whom are shown in the photograph on page 1222, there are representatives of ten nations.

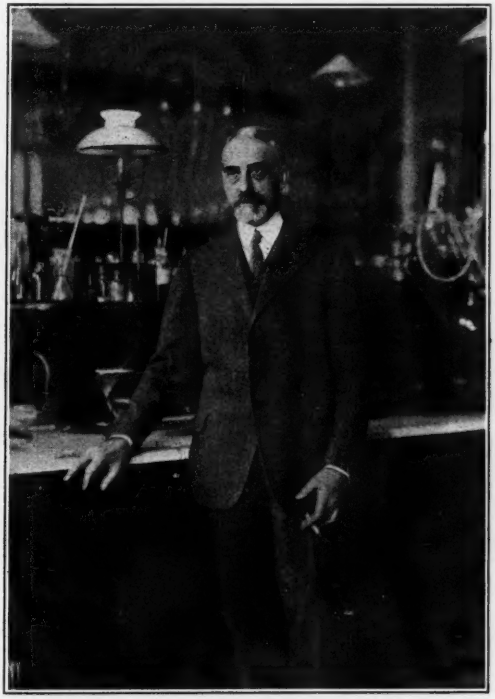
Laboratory of Therapeutical Chemistry

This laboratory is one of the relatively recent additions to the scientific community which makes up the Pasteur Institute. It was created January, 1911, and from the beginning has been under the direction of M. Ernest Fourneau. It is devoted to researches having for their object the discovery and study of chemical compounds specific for the cure and prevention of diseases, particularly those of a contagious character.

It has been pointed out by M. Fourneau that, following the various studies upon trypanosomiasis and the brilliant discoveries of Ehrlich, the possibility has been recognized of sterilizing an infected organism by the introduction into the blood of a chemical agent which, in the manner of "the enchanted projectile of Freyschütz" reaches directly the parasite, without injuring notably the organism which harbors it. In a word, chemotherapy, in contradistinction to pharmacotherapy, properly called, has for its object the suppression of the causes of diseases and not merely the attenuation of their effects.

Chemotherapy is a creation too recent not to be empirical. Except in a very small number of cases, no prediction can be made as to how a chemical compound acts upon a parasite *in vivo*. Instinct must then play a

large role in therapeutical chemical researches, especially if one goes beyond the two or three series of compounds among which have been hitherto found the best specifics (arsenicals, mercurials, quinine). Furthermore, the chemist should be prepared to direct himself rapidly towards the faintest clearing which pierces the clouds. He should keep himself acquainted with the literature and ask the support of all those who, in any fashion, devote themselves to therapeutics. Chemotherapy requires, therefore, a close



Dr. Ernest Fourneau, Chief of the Therapeutical Chemical Laboratory of the Pasteur Institute.

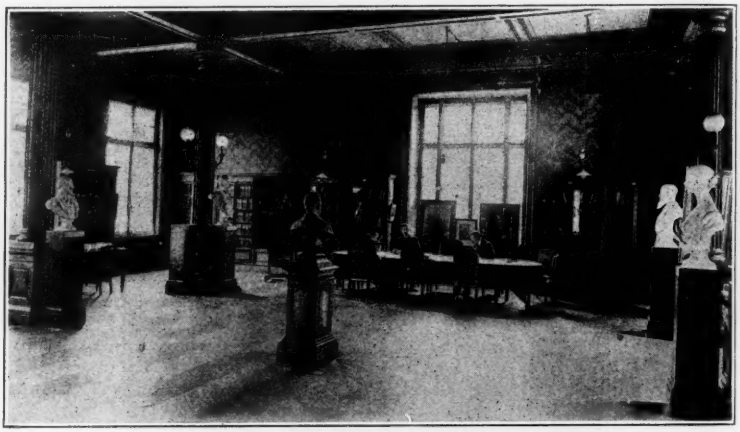
association between chemists, bacteriologists, pharmacologists and physicians. In order to vanquish a microörganism it is necessary to know its habitat and morphology; to know, on the other hand, the fate in the host of the medicaments or means by which one hopes to be able to get rid of the parasite. Finally, the last word rests with the physician.

The laboratory of M. Fourneau is, therefore, one in which a group of highly trained chemists is concentrating its attention upon the preparation of new organic compounds, the therapeutic properties of which are

caused to vary in a desired manner by the systematic variation of their molecular structure. Since the founding of the laboratory, attention has been directed to compounds containing mercury and arsenic and to certain alkaloids and dyes.

A striking recent accomplishment has been the discovery of the structure of the German remedy against sleeping sickness known as Bayer 205. The secret of the composition of this compound was carefully guarded by its discoverers and no patents or other publications in regard to it appeared. The suggestion was made that the value of this remedy to the Allies was comparable to that of the colonies lost by Germany during the war.

In spite of the complexity of the molecule in question its exact structure was established by means of a long series of experiments in the laboratory



Pasteur Institute—The Library.

of M. Fourneau and its synthesis was accomplished. The product is now being tried on a large scale in some of the African colonies of France, Belgium, and England. The results, so far, have shown that its value resides more in its preventive than curative power.

This remedy differs from those previously employed in chemotherapy in that it does not contain either arsenic, antimony, mercury or bismuth and is not a dye. It is an assemblage of two aminonaphthalenesulfonic acids, two aminobenzoic acids, and two methylaminobenzoic acids. The whole forms a compound of very high molecular weight (1448), which is larger than that of the most complex medicament hitherto employed.

In addition to the studies made of this compound in the laboratory of M. Fourneau much attention has been given to arsenicals. The basis of most of this work was the view that the comparisons which have so far

been made between pentavalent and trivalent arsenical derivatives are not sufficiently numerous or definite to warrant the rejection of the former group, the use of which appears to offer many advantages. For this reason more than a hundred pentavalent arsenical compounds have been made and tested. It has been found that many of them are not only free of all deleterious action upon the nervous system but show a chemitherapeutic coefficient (ratio between the curative and the toxic dose) as high as many arseno derivatives.

Very interesting relations between the constitution of the compounds and their therapeutic action have also been found. Thus, it has been shown that acetylation of the amino group reduces the toxic action as

Pasteur Institute—A Laboratory.

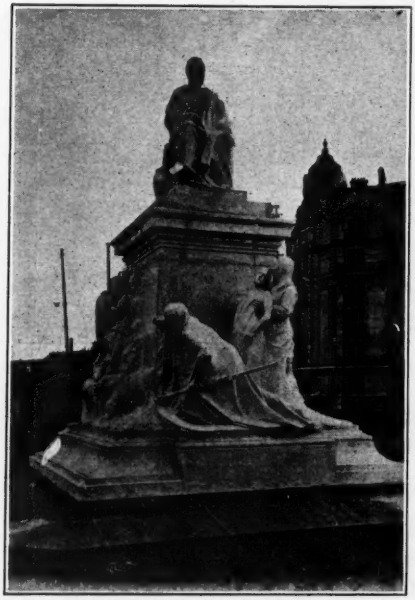
well as the curative action, except when the amino group is in the para position. In this case the therapeutic index is raised by acetylation. Many of the compounds made in this research have been tested not only upon laboratory animals, but also by specialists upon trypanocidal diseases in Africa. The results have shown that the large mammals and man do not respond to the compounds in a manner parallel to that obtained with small laboratory animals. This makes it impossible to select from the hundreds of compounds by means of tests in the laboratory, those worthy of tests in the field. All the products must, therefore, be sent to the regions where trypanosomiasis exists and the results of the tests awaited sometimes for one or two years and, furthermore, not a few grams, but many kilograms are needed. The necessity of large and liberally endowed research, therefore, becomes more and more apparent.

It fortunately sometimes happens in the course of researches in chemotherapy that remedies for which a certain use has been predicted later find entirely different applications. It is thus that among the compounds prepared in the laboratory of M. Fourneau an arsenical derivative, now better known as Stovarsol, was first tested against syphilis by administration by mouth. Later it was found, in the hands of Professor Marchoux, to be a remarkable remedy against amœbic dysentery and one of the forms of malaria.

This example illustrated the importance of testing new remedies in all directions and is further evidence of the necessity of organizing therapeutical chemical research upon the broadest possible scale.

Laboratory of Fermentations

The director of this laboratory is M. A. Fernbach, who began his studies upon fermentation in 1881 under the direction of Emile Duclaux. It is here that one of the most fruitful fields of Pasteur's activities is being intensively cultivated and greatly enlarged. As mentioned previously, a course of instruction in fermentation, which was begun in 1900, still constitutes one of the functions of this laboratory. Another is the publication of a journal of fermentation research, *Les annales de la Brasserie et de la Distillerie*, which is now in its 25th year.



Statue of Pasteur erected in the Place de Breteuil (Paris) by International Subscription.

The instruction consists in practical courses in microbiology and biochemistry applied to the fermentation industries, and also lectures given by M. Fernbach during the months of November to February, inclusive. The laboratory work consists in the cultivation of organisms, the study of the industrially important enzymes and, in general, all analytical determinations required in the chemical and bacteriological control of fermentation industries. The classes usually consist of from ten to twenty students.

The equipment of the laboratory includes a complete experimental

brewery designed on the cascade system and occupying six stories of the building. This installation makes possible the testing on a semi-commercial scale of improved processes for the manufacture of beer. One of these recently tried involved the substitution of moulds for malt in the saccharification of the starch.

The laboratory also contains rooms devoted to the culture of yeasts, and maintains a collection of more than 250 tested varieties. These standard yeasts are employed as reference cultures by the wine industry of France. In special cases new strains of yeasts are developed by selection as, for example, those with high coagulating and clarifying power required in the second fermentation of champagne. Some of the larger producers of champagne obtain their entire supply of these special yeasts from this laboratory.

Statue of the shepherd Jupille, wounded while protecting some children from the attack of a mad dog and subsequently saved by Pasteur's antirabic treatment.

In addition to the permanent staff of the laboratory there is a group of investigators who are pursuing various problems in connection with fermentation. In general, it may be said that the research has for its central idea the production of desired compounds by the selective action of ferments grown under judiciously varied conditions. In this laboratory was elaborated the process for the production of acetone and butyl alcohol which is now industrially employed on a tremendous scale, especially in America.

The extreme importance of the reaction of the medium upon the physiological properties of microbes was early recognized by M. Fernbach. He found that extract of malt which contains amylase was acid to phenolphthalein and alkaline to methyl orange, due to the presence of primary and secondary phosphates of potassium. Numerous experiments showed that the mixture of phosphates protected the diastase against the inhibiting effect of too great changes in the reaction of the medium. In 1900 he suggested for this action the name *tampon*, which, translated as buffer,

has been adopted in the current language of biochemists throughout the world. The study of the influence of the reaction of the medium upon biochemical phenomena now dominates all research upon enzymes, toxins, antiseptics, metabolism, etc., and has taken a great stride since the introduction of the conception of hydrogen-ion concentration which has permitted the more precise evaluation of this factor.

The development of the conception of hydrogen-ion concentration has been admirably described by M. Schoen, one of the assistants of M. Fernbach, in an address which was published in the June and July, 1924, issues of the *Annales de la Brasserie et de la Distillerie.* The methods for the control of the reaction of the medium as well as procedures employed for regulating the production and permitting the isolation of desired compounds are also discussed. It is pointed out, for example, that in the conversion of sugar into alcohol by the action of yeast, there are formed various intermediate compounds which may be of greater interest than the final products. By modifying the reaction of the medium as well as by the addition of reagents which unite with the intermediate compounds and permit their isolation, the normal course of the fermentation can be profoundly changed. It is by such procedures that a great variety of desirable products can be obtained, and light thrown upon the course of biochemical reactions. One of the compounds isolated many years ago in this laboratory, by simply conducting the fermentation in presence of chalk, was pyruvic acid. The question as to the source of this acid and the mechanism of its production from sugar has been the subject of a long and fruitful series of studies by M. Fernbach and M. Schoen.

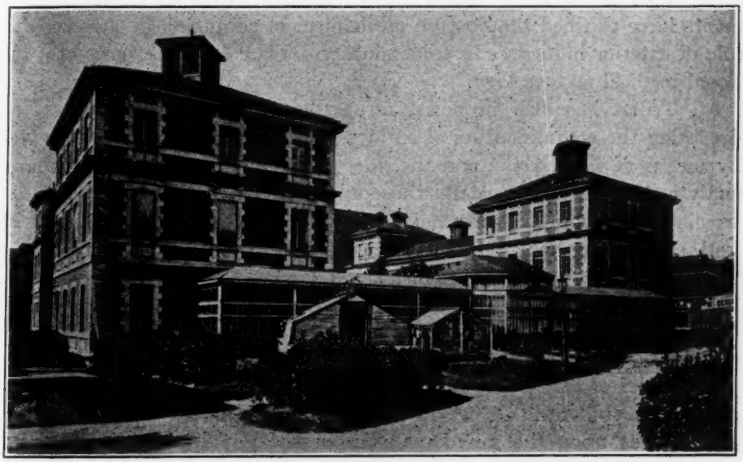
Statue of Pasteur at the Sorbonne (Paris).

Finally, it should be mentioned that in addition to his extensive studies upon fermentation M. Fernbach has contributed a remarkable series of papers upon the chemical nature of starch, one of the most important

raw materials used in the fermentation industry. This series of experiments began with the discovery, made in collaboration with M. Wolf, of a process for preparing soluble starch. The original observations along this line have formed the basis of numerous contributions upon this subject.

Laboratory of Chemistry Applied to Hygiene

This laboratory was organized in 1905 by M. A. Trillat who had previously been in charge of the analytical work of the Institute. To him is due the discovery in 1889 of the antiseptic and microbactericidal property of liquid and gaseous formic aldehyde, the commercial preparation of which he designated as "formol" to distinguish it from pure formaldehyde. He also developed an industrial process for the preparation of the



The Pasteur Hospital.

compound and devised practical methods and apparatus for its use in disinfection. This method soon supplanted, throughout the world, practically all other processes of disinfection which were in use at that time.

The mechanism of the action of formol, depending upon its property of rendering albuminoid substances and consequently the protoplasm of germs insoluble has been studied in all its details by M. Trillat and his associates. From these studies interesting industrial applications have been drawn. One of the principal of these has been the manufacture of new plastic materials, having casein for their base and serving as substitutes for the inflammable celluloid.

The discovery of the property of formic aldehyde of instantaneously combining with gases evolved during putrefaction, to yield odorless

derivatives, permitted him to propose formol as a deodorizing agent. The study of acetic aldehyde was inseparable from that of formic aldehyde and led him to numerous experiments on the formation of acetic aldehyde in fermentation and upon its rôle in the alteration of certain foodstuffs as, for example, the aging of wine, the souring of milk, curing of cheese, the phenomenon of caramelization, etc.

He studied the influences which favor the transmission of diseases by the air, and more particularly the rôle of humidity and some other meteorological factors. He made the curious discovery that microbes in suspension in the atmosphere become nuclei for the condensation of droplets. These are drawn along by air currents and when deposited on meat or on other foodstuffs cause their rapid putrefaction. It is not in the state of dusty dryness that he considers microbes to convey diseases. His experiments have clarified the obscure mechanism of contagion in showing the rôle of exterior influences in epidemiology. They form the basis of a rational medical meteorology.

M. Trillat has also proposed an extremely convenient process for disclosing the contamination of springs and subterranean sheets of water by means of fluoresceine and the fluoroscope. He has developed many analytical processes, especially those applicable to foods, such as the determination of formol, methyl alcohol, albumin, glycerol, and of traces of lead, etc. Pharmacology and therapeutics are indebted to him for many important discoveries, among which are urotropine (hexa methylene tetramine), the mineral and organic phosphoglycerates and phosphoglyceric acid.

Laboratory of Agricultural Chemistry

The chief of this laboratory, M. Pierre Mazé, entered the Pasteur Institute as a student in 1896. His thesis, presented in 1898 for the doctor's degree, was upon the microörganisms of the nodules of legumes. His researches since that time have been concerned principally with the nutrition of plants and of microbes. He has also made numerous studies upon the microörganisms required in the dairy industry. In the case of his experiments upon plant growth he developed a technic for maintaining aseptic conditions and thereby eliminating disturbances resulting from the multiplication of microörganisms in the culture solutions. Since, under these conditions, the nutrient medium supplies the entire mineral needs of the plant and receives only that which the plant yields to it, the exchanges which take place may be determined at any moment by analysis. The rôles of different elements and the influence of composition and concentration may thus be accurately followed. This method has been applied in all sorts of combinations and such properties demonstrated as the power of the roots to absorb soluble and insoluble organic materials, as well as their ability to excrete mineral and organic substances, and to cause the

reaction of the culture medium to change either towards the acid or alkaline side.

It has been found that for the normal development of corn to maturity of the grain, 15 mineral elements, in addition to carbon, hydrogen, oxygen, and sodium, are required. The protoplasm of corn must, therefore, contain organic combinations of quite a large number of elements, thus indicating the extreme complexity of living matter. The consequences to the plant resulting from the absence from the culture medium of each of these constituents have been the subject of individual experiments.

It is apparent that the juices of plants normally contain a great variety of elements probably as organo-metallic compounds, which are present in amounts corresponding in minuteness to the quantities of vitamins effective for animals. The rôle of these elements may be that of physiological excitants as supposed by Duclaux, or of catalytic fertilizers as suggested by Bertrand.

The prolific work of M. Mazé and his associates has shown that hitherto unrecognized nutritive factors play a rôle of as great importance in plant growth as do vitamins in the case of animal growth. The most recent observations have tended to confirm the parallelism in these two fields.

Laboratory of M. Jacques Duclaux

Of the two sons of Émile Duclaux one has followed in the footsteps of his father and since 1904 has pursued research at the Pasteur Institute—devoting his attention particularly to the application of physical chemistry and especially of colloidal chemistry to biological problems. He has published two books. The first is upon "The Chemistry of Living Matter" and the second upon "Colloids." This latter is now in its third edition. Many of his investigations have been upon problems concerning colloids and the practical application of this knowledge. He has also given much attention to catalysts and diastases, to adsorption, the properties and constitution of water, photochemistry, valence, ultra-violet rays, and miscellaneous problems of a more or less purely physical character.

Laboratory of Physical Chemistry

In this laboratory M. H. Mouton has studied, among other things, the physical chemical factors which intervene in biological phenomena. He has investigated, for example, the action of the electric current upon ciliated infusoria and showed that paramœcia follow the lines of the current without being influenced by the products formed at the electrodes. On the basis of this observation a procedure for collecting large numbers of individuals was developed and these later employed for the extraction of a proteolytic ferment.

His attention was early directed towards the "ultramicroscope" and

together with M. Cotton he devised a simplified form which served for the study of colloidal liquids. Of these, inorganic colloids such as ferric hydroxide were first studied, and especially their property of birefringence in the magnetic field. This phenomenon is the result of the orientation of ultramicroscopic particles in the liquid and is influenced by the temperature, the intensity of the field and the mode of preparation of the solutions. These observations and others upon thin films led to the formulation of a theory of colloids which has been developed in a treatise on "The Ultramicroscope and Ultramicroscopic Objects." Upon extending these studies to organic substances it was found that nitrobenzene and a whole series of compounds, principally cyclic organic compounds, become birefringent in the magnetic field. Compounds of the aliphatic series, with the possible exception of those containing sulfur do not show this property. After having studied the variation of the phenomenon under different conditions it was attributed to an incomplete orientation of the molecules of the compound in the magnetic field, analogous to the birefringence of various pure liquids in the electric field, known for a long time as the phenomenon of Kerr.

Although this work appears to be far removed from biology and, in fact, nearer pure physics, it must be remembered that it was the optical properties of certain organic compounds that led Pasteur to his biological researches. The study of all physical properties which throw light on the structure of the molecule may be expected to serve, sooner or later, the progress of biology.

It is to M. Mouton that French scientists are indebted for the translation of the books of Jacques Loeb upon "Proteins" and "Colloidal Properties."

Laboratory of M. G. Malfitano

During the many years of M. Malfitano's connection with the Pasteur Institute he and his collaborators have devoted themselves unremittingly to the study of colloids. Their efforts have been directed particularly to discovering the similarities and the differences between colloid particles or micelles and molecules. The name micelle has been chosen to denote isolated complex molecules existing in the ionized state. The very characteristic discontinued and progressive manner in which these colloidal particles flocculate and deflocculate has been revealed. This mode of variation in the state of division being essentially different from the continuous character of solution and crystallization, furnishes a natural classification for the distinctions pointed out by Graham.

The causes and mechanism of coagulation are believed to be due, on the one hand, to the impossibility of the micelles remaining isolated when nonionized, and on the other hand, to their aptitude to group themselves in a limited number around an electric nucleus, complex ion, or another micelle

of the same species. The various explanations which have been suggested are based on microscopic observations of the micelles appearing as perceptible molecules which combine in fixed proportions to form ions of which one is visible.

The method of ultrafiltration has been used for much of this work and the perfection of its technic, particularly in the matter of permitting sterilization and the use of very small quantities of liquids, as well as the question of the relation of resistance to tearing to permeability of collodion membranes, has received considerable attention in the laboratory of M. Malfitano.

By means of a systematic study of the many factors involved, membranes have been prepared which permit the delivery of 10 cc. of water per hour instead of only one or two cc. per square centimeter under one meter of pressure.

The researches upon starch, which have been pursued for many years, have yielded a great variety of observations which appear to confirm the hypothesis developed by M. Malfitano. According to this, starch is probably composed of alkaline earth amyloso-phosphate and amylososilicate complexes, either acid or neutral. Amylose, $C_6H_{10}O_5 \cdot H_2O$, is present in a preponderating degree as compared with the salts. There are from 100 to 300 molecules of amylose per atom of phosphorus, and the number of atoms of silica is ten times less than those of phosphorus in potato starch and about one-half in corn starch. Many other details of the structure of the starch molecule have been studied and a picture is gradually being traced which, it is hoped, will eventually portray the true chemical character of this highly important biological product.

Laboratory of M. Mestrezat

This, like the laboratory of M. Malfitano, forms a part of the Division of Physiology of the Pasteur Institute which is under the general direction of M. Delezenne. The work of M. Mestrezat is concerned with the application of chemical analytical procedures to various normal and abnormal body fluids, and particularly the cephalo-rachidien liquid. This subject is treated in detail by M. Mestrezat in a book of 740 pages entitled "Le Liquide Cephalo-Rachidien—Normal et Pathologique" published by him in 1912. The chemical examination of the humor obtained by lumbar puncture provides the most satisfactory method at present known for the diagnosis and prognosis of nervous and related diseases. The work is still being pursued and advances made in the technic employed and in the interpretation of the analytical results obtained.

In addition to this general problem M. Mestrezat has also devoted much attention to cellular permeability and nutrition, especially from the point of view of the etiology and growth of malignant tumors. He has studied

the composition of the exudates of wounds and used the results to diagnose the right period for suturing. Furthermore, he has undertaken a general study of metabolism in anesthesia and the dietetic or therapeutic circumstances which accompany it. In connection with these various problems numerous improvements in analytical technic have been made and it is along this line that the contributions of M. Mestrezat have been especially noteworthy.

Laboratory of Research upon Biological Chemistry and Microbiology

M. Albert Berthelot who has charge of this laboratory entered the Pasteur Institute in 1900 as assistant in the laboratory of M. Trillat. He later, in collaboration with Professor Metchnikoff, did the chemical work in connection with the long series of studies upon intestinal flora. This included the investigation of such questions as the biochemical properties of various organisms, the poisonous and other products evolved by them, and methods for combating their harmful effects, such as lactic bacteria and vaccine therapy.

During the war he studied the formation of ptomains in wounds and in recent years has devoted his attention to biochemical studies upon pyruvic acid and the chemical composition of tubercular and other bacilli.

Laboratories of M. Levaditi and of M. Sazerac

In the case of the work carried on in several laboratories the incidental aid rendered by chemistry may not be recognized. This is true particularly of those experiments in which the curative effects of various substances upon particular diseases are tested. Well-known compounds may be chosen and the aid of a chemist only rarely required for the preparation of new forms or combinations of a given substance. This has been the case with the extensive work of M. Levaditi in collaboration with M. Sazerac and others upon the curative and prophylactic effects of bismuth and its compounds upon syphilis.

The experiments were begun in 1920 and encouraging results were immediately obtained. It has now been established that different salts of bismuth, in particular the tartro-bismuthate of sodium and potassium, and even colloidal metallic bismuth itself causes the rapid cicatrisation of the lesions of syphilis at all stages. Bismuth has also been found of prophylactic value. Its therapeutic action is certainly superior to that of mercury and comparable to that of the best arsenicals. The curative effects of bismuth appear to be intimately connected with the slow absorption of the metal and to its persistence in the infected organism. The disease is thus treated for a long time after the doctor has ceased to administer the remedy.

Laboratory for the Preparation of Toxins

Among the other divisions of the Pasteur Institute in which chemical principles are being applied to the solution of various types of problems, should be mentioned that concerned with the preparation of the toxins required for the large scale production of antitoxins. Here Dr. George Abt is seeking by mainly chemical studies to improve the potency and constancy of these extremely important products.

Since the demonstration of the efficiency of diphtheria antitoxin by Dr. Roux more than thirty years ago relatively little progress in its improvement or explanation of its action has been made. Products of satisfactory potency and constancy have been developed gradually by practical experience obtained over a long period. During this time it has been learned that the more highly active the toxin, the more concentrated and efficacious will be the antitoxin prepared by its aid. Attention has, therefore, been directed particularly towards improving the toxin. The factors involved in this are, however, so imperfectly known that workers in different laboratories rarely succeed in preparing equally potent toxins even by following, as nearly as possible, the same procedure. It has consequently been found necessary to study minutely those factors which have not hitherto been considered of vital importance.

Since toxin is a product of the growth of a bacillus in a culture medium it is necessary to consider the food supply in general as well as the relation of particular constituents of the medium to the production of toxin. Furthermore, the conditions under which the organism utilizes its food supply, as for example, the concentration and reaction of the medium, must be taken into consideration.

In regard to particular constituents especial attention has been given to the consumption by the organism of the salts of organic acids, chiefly acetic and butyric, which are produced in the preliminary short putrefaction of the meat used for preparing the broth. These salts play an important part in controlling, by their buffer action, the hydrogen-ion concentration of the medium. They also contribute to the energy requirements of the organism in being converted, together with other carbon compounds derived from peptone, into carbon dioxide. In this connection the carbon metabolism of the organisms has been minutely studied and, from a quantitative standpoint, found to be of greater importance than the nitrogen metabolism.

An interesting observation has been made in regard to the apparent effect of season upon the potency of the toxin produced by the diphtheria bacillus. Whether this is due to a variation in the activity of the organism at different seasons of the year or is the result of a seasonal change in the composition of the nutrient material is not known. Experience has shown in this connection that bacteria grown upon broth made from the very

light-colored meat of veal produce more potent toxin than those grown upon broth made from the meat of older animals. It may also be possible that similar variations have their origin in differences in the composition of the meat used for the broth, resulting from seasonal changes in the food supply of the animals. Deductions of this character support the view that toxin is produced by bacteria from very specialized compounds present in the medium in extremely small and variable quantity.

In recent years it has been shown, chiefly by Ramon, that by slow treatment of toxins with formaldehyde in an incubator, their toxicity can be greatly reduced without diminishing their antigenic power. With such preparations very large doses can be used for the immunization of horses and thus sera of exceptionally high antitoxin value can be very quickly produced. Furthermore, detoxicated toxin can also be used for conveying immunity to human beings and serves to replace the somewhat unsatisfactory mixtures of toxin and antitoxin hitherto used for this purpose.

The most recent developments in this field have, therefore, been the attempts to purify the detoxicated toxin by salt precipitation and dialysis and thus obtain immunizing material containing as little extraneous impurity as possible. The procedures have so far led to the removal of more than 90 per cent of the nitrogen not associated with the active product. It is along this line that it is expected greatest advances will be made.

Conclusions

As compared with similar research institutions in other countries, the Pasteur Institute is noteworthy for the informality of its organization, and the international character of its personnel. It is simply a community of scientists drawn together by the incentive of favorable conditions for work rather than pecuniary remuneration. Those who direct the Institute are principally concerned with providing adequate facilities and inspiration to persons of proven qualifications for research. There is perhaps no other research institution where so little regulation of the activities of the workers is exercised. The only requirement is the advancement of science.

There are several large divisions or services which are subject to variation in size and function in accordance with the changing needs of the work and the qualifications of the workers. In addition, independent units are established whenever the occasion demands. Some laboratories are classified by the type of research being pursued and others simply under the name of the scientist in charge. Close coördination of the problems is not attempted. Several persons may be working quite independently upon the same subject. Each one is guided simply by his inclination and aptitude. With few exceptions there are no large groups attacking a given problem under one leader. No periodical reports of progress are

required and no justification of expenditures is exacted. No other records of the progress of the work are kept than are set forth in the individual publications of the members of the Institute. Even the Director is probably not conversant with all the lines of research being pursued.

In the preparation of this brief account of chemical research at the Pasteur Institute it has been necessary to rely largely upon personal contact with those engaged in the work. The opportunities for this have varied, and equally detailed information has not been obtained in all cases. It is certain that many important lines of research have been overlooked and others quite inadequately described. There are, furthermore, many problems in which the contributions of chemistry can be discovered only by very careful search.

As already mentioned, the doors of the Pasteur Institute are open to serious workers of all nations. Those from America who may wish to avail themselves of its facilities will receive a warm welcome. The qualifications of the present staff are sufficiently diversified to insure that for almost any problem pertaining to medical or biological science which one may desire to pursue, there will be found someone at the Pasteur Institute whose advice and council will be helpful in its solution.

Although a speaking knowledge of the French language is not necessary, its acquirement will well repay the effort involved. To aid those who are ambitious in this regard, several French universities offer summer courses for foreigners, and it is possible for persons arriving in France in the spring or early summer, to obtain a sufficient start during the summer vacation to permit them to rapidly derive the maximum benefit from their association with the scientists of France.

At the Pasteur Institute will be found representatives of almost every nation, either as members of the staff or students pursuing research. Although cosmopolitan in its personnel, the Institute is united in its purpose to advance the boundaries of science.

Government Experts Make Minute Analysis of Dental Gold. The victim in the dentist's chair may look forward to more satisfactory and permanent gold fillings for his defective molars.

A method for more complete analysis of dental gold alloys than has hitherto been possible has been perfected at the U. S. Bureau of Standards. It is now possible to make accurate studies of the various effects derived from putting different kinds and quantities of metals in the alloys. Manufacturers in consequence will be able to guarantee with more certainty the exact qualities of the product they can furnish to the man who manipulates the little drills.

Forty different alloys of the kinds used by dentists throughout the country were recently analyzed in the studies made in the Bureau of Standards laboratories.—*Science Service*

THE VITAMINS. I*

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Terminology of Vitamins A, B, C, D and E

Of all scientific subjects and occupations, chemistry is perhaps the broadest. There are fields of chemistry in which the methods and objectives would be foreign to anyone but a chemist. There are also important fields of work for the chemist which call for a broadening of chemistry toward physics on the one hand and toward physiology or biology on the other. In recent years the broadening of chemistry toward physiology and the growing custom of using animals as laboratory tools and reagents, especially in the chemistry of food and nutrition, has resulted in the discovery of a whole group of substances whose existence was previously unknown but which are now seen to be absolutely essential factors in nutrition and, therefore, in any adequate conception of food values. These substances, now commonly known as the vitamins, are chemical individuals even though not yet chemically identified. In this respect they are in a similar position to most of the enzymes, toxins, and antitoxins. Like these latter substances, the vitamins are known by their effects rather than being identified (as are the simpler substances) by means of their physical properties. But just as a substance supposedly identified by its physical properties may be differentiated by further research, or as a reaction first supposed to be characteristic of one substance may later be found to be true of two or more, so it is possible that any of the vitamins as we now know them may prove to be two or more substances of similar or inter-related behavior in nutrition rather than a single chemical individual. It is well to realize clearly that the possibility of such further developments does not detract from, but rather adds to the importance of a full and accurate understanding of the knowledge now available. In this series of short reviews, space will not be available for the setting forth of a full account of our present knowledge of the vitamins, but it is hoped that a glimpse may be afforded which will emphasize to the reader the importance of the attempts which are now being made to advance our knowledge in this field, not by qualitative methods alone or chiefly, but also and especially by the rigorous quantitative methods of exact scientific research. It is chiefly by quantitative research that our qualitative conceptions are now being advanced and clarified.

When, through the work of many investigators among whom Hopkins, Osborne, and Mendel and McCollum and Davis are deserving of special mention in this connection because of the clearness with which they connected the vitamins with normal nutrition, it appeared that at least two

* This is the first of a projected series of five papers to deal, respectively, first with the water-soluble vitamins B and C and then with the fat-soluble vitamins A, D, and E.

previously unknown substances are essential to the adequacy of the food supply, McCollum proposed that these be called "fat-soluble A" and "water-soluble B," and expressed the belief that the latter was identical with the water-soluble substance which Funk had called *vitamine*. And at about the same time the work of Holst and Frölich furnished good evidence that the prevention of scurvy depends upon another nutritionally essential substance which then came to be called antiscorbutic vitamine or water-soluble C.

In 1920, Drummond suggested that the designations then in common use be combined and simplified by naming the three substances Vitamins A, B, and C, respectively—the omission of the final "e" from the group-name freeing it from the original implication that these substances are amines in their chemical nature.

The terminology thus introduced by Drummond came rapidly into general use and since 1920 all qualified students of the subject have recognized the existence of at least the three vitamins, A, B, and C; though perhaps not all have recognized with equal clearness that any one of these terms as originally introduced might, with the growth of knowledge through further investigation, be found to have covered more than one substance. As a matter of fact, the subsequent additions to the vitamin alphabet have arisen not so much as wholly new nutritional conceptions as by differentiation.

Whereas formerly the terms vitamin A and fat-soluble vitamin were employed interchangeably, there have now been differentiated two fat-soluble factors not identical with vitamin A or with each other. These are the antirachitic substance now usually called vitamin D,[1] and a substance essential to reproduction (though no more so than is vitamin A), which was discovered by Evans and by him at first designated as "X," but is now commonly known as vitamin E.

As explained in what follows, there are increasingly numerous indications that more than one substance may be involved in the phenomena hitherto attributed to vitamin B. If and when the evidence to this effect becomes sufficiently convincing, there will be occasion either to differentiate one or more substances *from* the substance known as vitamin B, or to differentiate vitamin B *into* two or more substances, for example, as suggested below, into vitamins F and G.

The Water-Soluble Vitamin B

(*and the problem of its possible differentiation into vitamins F and G*)

For a long time the nerve disease beriberi was very common in the Orient. Less than fifty years ago the entire enlisted force of the Japanese

[1] The term vitamin D has also been applied by some writers to the substance generally known as *bios*, which may be related to vitamin B. Bios may best be discussed in a separate paper. See also Tanner, *Chem. Rev.*, 1, No. 4 (1925).

navy numbered only about 5000 men, and of these from 1000 to 2000 were sick each year with beriberi. An annual morbidity of 20 to 40 per cent from a single disease is, of course, enormous; and Takaki, a medical officer, determined upon an investigation. He reasoned that the cause of the disease was probably in the ration because it did not attack European sailors in the Orient who continued to subsist upon the European type of diet, while Japanese sailors under similar climatic and sanitary conditions, but living on the Japanese naval ration which consisted mainly of white rice, suffered severely. Thus in one case a Japanese naval vessel with 276 men on a nine months' cruise in the Pacific had 169 cases of beriberi with 25 deaths. Takaki succeeded in having another vessel with a similar crew sent over the same route but with a ration in which the rice was decreased, barley increased, and vegetables, meat, and condensed milk added. In this case only 14 men had beriberi and each of these had failed to eat his share of the new foods. Takaki was then able to secure the adoption of his new ration for the entire Japanese navy and beriberi practically ceased to occur among its men. Takaki was explicit and, as we now know, correct in attributing the eradication of beriberi to the change of ration; but this view did not find general acceptance nor did his really great achievement do the good that it should have done, because he offered no adequate scientific explanation. He discussed his improvement of the ration only in terms of its protein or nitrogen content, which others rightly regarded as unconvincing, and opinion continued to be divided as to whether beriberi were a nutritional or an infectious disease.

In 1897, Eijkmann, a Dutch physician then working in the East Indies, published the results of a large number of observations which he had made upon "an illness of fowls similar to beriberi," which he was able to produce by feeding the fowls upon polished rice and to prevent or cure by feeding the rice polishings or an extract of them. Probably this was the first experimental production of a nutritional deficiency disease; but Eijkmann did not, until many years later, give his work a clear chemical or nutritional explanation, but rather interpreted his results with what the British have called "so strong a pharmacological bias" as to obscure their true nutritional significance.

It was Hopkins who first clearly and convincingly stated the fact of the existence and nutritional significance of such substances as we now call vitamins.

Meantime others had carried on the work begun by Eijkmann in the Orient. Among these were Eijkmann's Dutch colleague, Grijns; the British investigators, Fletcher and Fraser and Stanton; and American army officers and scientific investigators who served in the Philippines during the first decade of this century. In the Bilibid prison at Manila, a serious outbreak of beriberi among the prisoners followed what had been

intended as an improvement in the food supply, namely, the substitution of a commercially higher grade of rice (white, polished) for the cheap brown rice which had constituted the mainstay of the prisoners' diet. At about the same time Fletcher, by experimenting with the diet in a lunatic asylum, showed that when 28 ounces of rice were fed daily with only small amounts of other food, the use of polished or unpolished rice was alone sufficient to determine the occurrence or non-occurrence of beriberi. Fraser and Stanton made similar observations upon parallel groups of Java laborers living in new and sanitary quarters in a virgin jungle. Chamberlain, Vedder, and Williams, of the United States Army Medical Commission in the Philippines, eradicated beriberi from the "Philippine Scouts" by changing the ration, and started a systematic investigation to find the substance having the property of preventing this nerve disease—the *antineuritic substance*. Funk, a Polish chemist working in London, also took up this investigation and was the first to claim the isolation of the substance and to give it the name *vitamine*. Funk's work confirmed that of Chamberlain, Vedder, and Williams in indicating that the substance is a nitrogenous base but not an alkaloid, and this view has been further confirmed by several other investigators; but this is about as far as a consensus of opinion has yet been reached regarding the precise chemical nature of the substance. Whether it will prove to be a substance quite independent of any hitherto known or, as suggested by Williams, a physiologically active and chemically unstable isomer of some known substance, is still an open question.

Williams found that acid hydrolysis of an extract of rice polishings apparently set the vitamin free from some combination in which it had existed, the vitamin of the hydrolyzed extract exerting a more rapid effect in the cure of beriberi but also more rapidly losing its curative property. That this vitamin may be kept a long time when stored dry in its natural state under favorable conditions is strikingly illustrated by the observation of Jansen that rice which had been successfully stored for 100 years appeared normal in its antineuritic potency.

It has been pointed out frequently and by several different investigators that the implication of identity involved in the use of the term vitamin B, both in connection with the water-soluble growth essential and the antineuritic factor, is only tentative. Most of the suggestions for the differentiation of vitamin B have been based upon the belief that the "water-soluble B" essential for growth may prove to be a *different substance* from the antineuritic vitamin; but quite recently it has been suggested that this growth essential may consist of *two* factors, one of which is identical with Funk's antineuritic vitamin and the other perhaps identical with Goldberger's pellagra-preventing vitamin and possibly also with bios. If it should prove true that a mixture of two different substances

is essential to the growth-promoting function attributed to "water-soluble B" then it would seem that neither of these alone would sufficiently fulfil the conception of "B" to warrant the assignment of this designation to either of the parts, but that both should receive new designations; and the writer would suggest that Funk's antineuritic substance be known as vitamin F, and Goldberger's pellagra-preventing substance as vitamin G. Vitamin B would then continue to mean the mixture of these two which is essential to growth and which is widely distributed among food materials and other plant and animal tissues.

At first thought it might seem that such a resolution of vitamin B into two factors would destroy the value of all statements which appear to assume the identity of the substance; but many, if not most, research workers have been fully aware that the assumption was only apparent and have so planned their researches that the results will still be of value if vitamin B should prove capable of differentiation into two (or even more) factors. The careful reader will probably be satisfied, upon reflection, that such statements as are made below regarding the results of research upon vitamin B will, in the main at least, not call for rejection but only for reinterpretation if it shall be found that the term vitamin B as hitherto used has covered more than one essential substance. In the case of quantitative feeding experiments to determine the relative richness of foods in vitamin B, the interpretation would become similar to that of experiments upon the nutritive efficiency of proteins, which always contain more than one nutritionally essential amino acid. Hence what follows has been written and will doubtless be read with the thought in mind that "vitamin B" may or may not be a single substance; but that in either case, whether it be simple or compound, the factor which has been known and investigated as vitamin B is important in connection with food and nutrition and the research which has been devoted to it has already yielded very significant results.

Perhaps it may be well to speak first, at this point, of the broad significance of vitamin B. So generally is it referred to as a growth essential or an antineuritic substance that it may be necessary to emphasize the fact that it is essential to nutrition at all ages, and that in case of shortage of vitamin B the characteristic neuritis is only one of several injuries which may result. In fact the body may suffer in several other ways before any signs of nerve disease appear. As Plimmer has recently expressed it: "Before the symptoms of beriberi appear, there is a period of ill-health in which occur common symptoms met with every day in medical practice. The first sign is loss of appetite.... Weakness, loss of weight, lack of vigor follow.... Later gastro-intestinal derangements appear—indigestion, constipation, colitis; finally there are symptoms due to the malnutrition of the nervous system. The onset of these symptoms varies according to

the degree of the shortage of vitamin B. The greater the shortage, the sooner they appear. If the shortage is slight, the nervous symptoms may never appear, and the organism suffers only from dyspepsia, constipation, and other intestinal troubles. The body is thus weakened and offers no resistance to invading microörganisms...." Findlay observed a lowering of body temperature and an increased susceptibility to bacterial infection in pigeons on diets lacking in vitamin B.

Even though they are weakened in their ability to resist bacterial infections and in other ways, pigeons and fowls almost always develop distinct nerve symptoms before dying from lack of vitamin B, but rats may die from lack of this vitamin through weakening of the body in other directions before clear evidence of the nerve disorder appears. · That shortage of the vitamin intake may greatly increase the susceptibility to bacterial invasion of the body has been strongly emphasized by McCarrison, who has also studied the effects of vitamin deficiencies upon the size, structure, and function of various organs—the discussion of which leads too far into physiology and pathology to fall within the scope of this review.

The relation of vitamin B intake to the appetite has been very clearly shown by the experiments of Osborne and Mendel and further emphasized by those of Kerr and of Cowgill working in Mendel's laboratory. The vitamin does more than merely to make the food appetizing; it in some way promotes appetite as a physiological function or condition of the body. Similarly, though less clearly, the liberality of the intake of vitamin B has been related to the proper functioning of the digestive tract, and to a possible more or less general function as "physiological stimulant."

Undoubtedly the best condition of nutrition and health requires that the food furnish much more vitamin B than is needed to prevent beriberi or even to sustain normal growth. Recent experiments of Osborne and Mendel demonstrate fully that, prominent as is the growth requirement, the amount of vitamin B needed daily by the body continues to increase as the body increases in size; and there is also evidence that still more vitamin B is needed during reproduction and lactation than at any other period of the life history.

There should, however, be no difficulty in so planning the dietary that the staple foods consumed shall furnish an abundance of vitamin B under all normal conditions; for vitamin B is probably of all the known vitamins (unless vitamin E), the most widely and uniformly distributed among the various parts of plants and animals which are used for food. Milk and the whole grain cereals seem to contain vitamin B in concentration at least three to five times as high as needed for the support of normal growth so that even the diet of an infant or invalid restricted to these foods should contain ample amounts of vitamin B unless the foods mentioned are too greatly diluted with vitamin-deficient foods such as sugar or highly milled

grain products. The fruit juices now commonly used with the cereal-and-milk diet of the infant or invalid are also important sources of this vitamin; and in the more varied diet usually consumed by the adult, many vegetables and fruits should add to the intake of vitamin B. Hence there is little danger of a deficiency of this vitamin except in those cases in which the diet consists too largely of artificially refined foods. Such cases may, however, occur even under conditions of reasonable prosperity and freely chosen food supply because of the great prominence of sweets, fats, and highly milled grain products in the dietaries of so many people; and because the vitamin B of the grains is so largely localized in the outer layers and embryos, and, therefore, is so largely rejected in the milling of the grains. A larger use of fruits and vegetables, whole wheat bread and other whole grain cereals, milk, and eggs may often be advantageous as increasing the intake of vitamin B as well as for other nutritional reasons.

Evidently it is of practical interest from the standpoint of food values and good nutrition, as well as of scientific significance for our understanding of the processes of plant and animal life, to know something of the distribution of vitamin B in nature.

The concentration of vitamin B in the embryo of the seed suggests its importance to the early life of the young plant. Later the plant doubtless synthesizes vitamin B; but how, when, and in what organs we do not know. It is found widely distributed in the plant body.

Animals doubtless derive their vitamin B either directly or indirectly from plants, and the animal organism does not seem capable of storing this vitamin to a sufficient extent to render it independent of the intake for any considerable length of time; yet in milk and in eggs we find a considerable concentration of vitamin B provided by the parent organism for the nutrition of the young. Perhaps it is because, under natural conditions, animals are receiving this vitamin so regularly in their food that they do not seem to have developed much capacity for storing it. The concentration may be increased in the liver if the food has been rich in this vitamin and may be depleted if the diet has been poor in vitamin B; but apparently neither the liver nor the body as a whole can be depended upon to store enough vitamin B to meet the requirements of nutrition for any considerable time without receiving new supplies in the food.

Quantitative determinations of the relative amounts of vitamin B in foods are of interest in many connections: as making more definite our knowledge of the distribution of this vitamin in nature and its role in plant and animal life; as affording a measurement of this factor in food value; as supplying a means of ascertaining the variations which occur under either natural or artificial conditions and gaining knowledge of the stability of the vitamin and the extent to which it is destroyed or otherwise lost under various conditions, such data being of scientific significance in the

study of the chemical behavior of the substance and, therefore, of its chemical nature, and of practical importance to the conservation of this factor of food value under the various conditions to which the food may be subjected in ripening, harvesting, marketing, storage, cooking, canning, or other industrial or household manipulation.

Fundamentally important as is the quantitative determination of the vitamin, space does not permit description of the process here. An outline and brief discussion of the method and a tabulation of results obtained upon a number of food materials have recently been published in the writer's "Chemistry of Food and Nutrition," third edition, pages 405–408.

The thermostability of vitamin B and the influence of hydrogen-ion concentration or activity (p_H) have been studied recently with the increased precision made possible by the development of the rat-growth method for its quantitative determination, and it has been found[2] that vitamin B is more stable on heating in the dry state than in solution, and that in solutions of favorable reaction it is more stable on heating, even up to 130°C. than was previously supposed, but that the rate of destruction of the vitamin when heated in solution increases markedly as the acidity of the solution is diminished or its alkalinity increased. Thus, dried milk showed no appreciable diminution of vitamin B value when heated for 48 hours at 100°C., while a solution of the same material showed a slight diminution upon heating at the same temperature for 6 hours; and tomato juice at its natural acidity of p_H 4.28 lost only about 20 per cent of its vitamin B value on heating for 4 hours at 100°C., whereas the loss (for the same time and temperature of heating) was increased to about 30 per cent at p_H 5.2, and to about 70 per cent at p_H 7.9. Oxidation was not found to be an appreciable factor in the diminution of vitamin B value in any of these experiments.

Summary is deferred until the completion of the remaining papers of this series.

Acknowledgment is due to The Macmillan Company for permission to draw upon the material of the 1926 edition of my "Chemistry of Food and Nutrition" in the preparation of this paper. The reader who wishes a selected bibliography may refer to pages 416 to 420 therein. Among books dealing specifically and more fully with the vitamins and giving bibliographies which are more complete on many points though of somewhat less recent date are: Eddy, "The Vitamin Manual;" Ellis and MacLeod, "Vital Factors in Foods;" Funk, "The Vitamins;" McCollum and Simmonds, "Newer Knowledge of Nutrition," 3rd ed.; Mendel, "Nutrition—The Chemistry of Life;" Sherman and Smith, "The Vitamins."

[2] Sherman and Spohn, *J. Am. Chem. Soc.*, **45**, 2719 (1923). Sherman and Grose, *Ibid.*, **45**, 2728 (1923). Sherman and Burton, *J. Biol. Chem.*, **70**, 639(1926).

FARADAY'S DISCOVERY OF BENZENE*

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Faraday announced the discovery of benzene in a paper read at a meeting of the Royal Society on June 16, 1825. His paper tells in simple language the story of the separation of this hydrocarbon from a complex mixture, the study of its properties, and the determination of its composition.

Faraday at the time of this discovery was scarcely thirty-four years old. He had been at the Royal Institution twelve years. Entering in 1813 as an Assistant with menial duties, he was promoted in 1821 to Superintendent of the House and Laboratory, and in 1825 to Director of the Laboratory. His position in the Royal Institution was now secure, and he was free to work as his genius directed. Moreover, he was recognized as a noted scientist, for in 1824 (January) he was elected a Fellow of the Royal Society. These honors came to him before he made his epochal discoveries which laid the stable foundations in the two vast fields of organic chemistry and applied electricity.

Faraday's account of his discovery of benzene was published in the Philosophical Transactions of the Royal Society for 1825. As far as possible I shall tell the story of the discovery in Faraday's own words taken from my copy of reprint of the original paper.

The raw material from which Faraday separated benzene was an oil obtained as a by-product in the manufacture of an illuminating gas by the destructive distillation of fish oil. Several years prior to 1825 the Portable Gas Company of London manufactured this illuminating gas by dropping whale, or cod, oil into a hot furnace, subjecting the gaseous product to a pressure of about thirty atmospheres, and storing the purified gas in portable vessels for use in public buildings and private houses. During the compression an oily liquid was deposited. From this liquid Faraday obtained benzene.

He became interested in this illuminating gas and its by-products five years, perhaps longer, before he obtained benzene. He says:

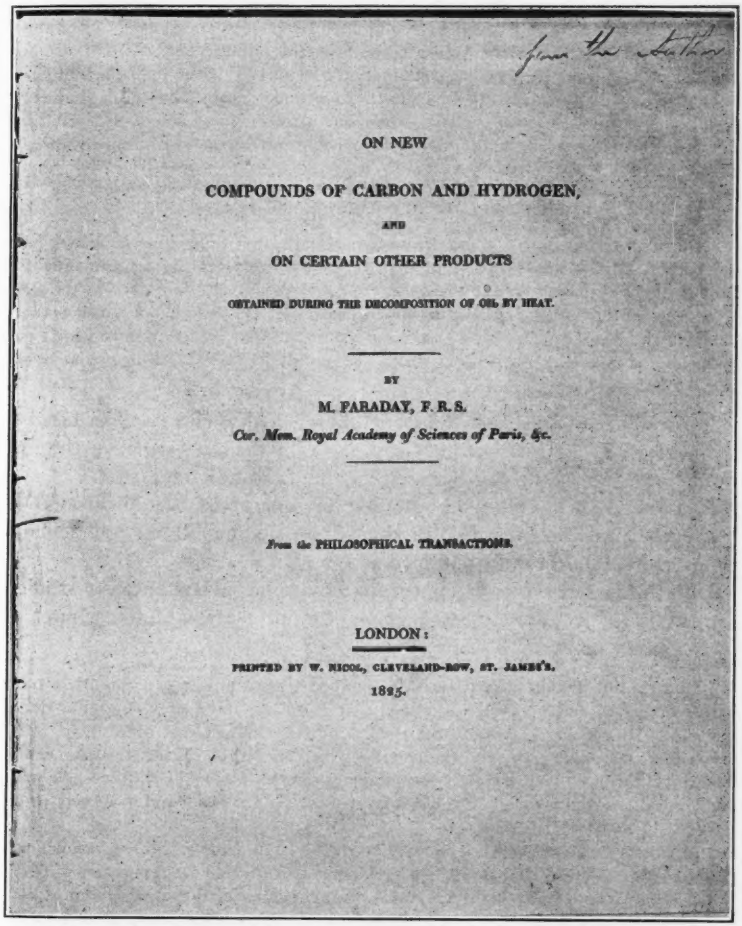
> My attention was first called to the substances formed in oil at moderate and at high temperatures in the year 1820; and since then I have endeavoured to lay hold of every opportunity for obtaining information on the subject. A particularly favourable one has been afforded me lately with considerable quantities of a fluid obtained during the compression of oil gas, of which I had some years since possessed small portions, sufficient to excite great interest, but not to satisfy it.

It is recorded by a reliable authority that Faraday began work on this oil April 26, 1825. The exact source of the fluid, as Faraday called the oil, is stated thus:

> It is now generally known that, in the operations of the Portable Gas Company, when the oil gas used is compressed in the vessels, a fluid is deposited, which may be

* Delivered at the joint meeting of the Division of Chemical Education and Section of History of Chemistry of the A. C. S. at Tulsa, April 7, 1926.

drawn off and preserved in the liquid state. The pressure applied amounts to 30 atmospheres; and in the operation, the gas previously contained in a gasometer over water first passes into a large strong receiver, and from it, by pipes, into the portable vessels. It is in the receiver that the condensation principally takes place; and it is from that vessel that the liquid I have worked with has been taken. The fluid is drawn off at the bottom by opening a conical valve; at first a portion of water generally comes out, and then the liquid.



From the Author

ON NEW

COMPOUNDS OF CARBON AND HYDROGEN,

AND

ON CERTAIN OTHER PRODUCTS

OBTAINED DURING THE DECOMPOSITION OF OIL BY HEAT.

BY

M. FARADAY, F.R.S.

Cor. Mem. Royal Academy of Sciences of Paris, &c.

From the PHILOSOPHICAL TRANSACTIONS.

LONDON:

PRINTED BY W. NICOL, CLEVELAND-ROW, ST. JAMES'S.

1825.

Title page of a reprint of Faraday's paper describing the discovery of benzene.

Faraday next describes the properties of this oil-liquid in detail, stating its varied appearance, oil-gas odor, rapid evaporation of the major portion,

low boiling point of most the liquid, specific gravity, solubility, and reaction with acids (especially sulfuric acid). He is particularly impressed by the evidence of a mixture, and after some preliminary experiments decided to subject the oil to fractional distillation. Thus he says:

With the hope of separating some distinct substances from this evident mixture, a quantity of it was distilled, and the vapours condensed at a temperature of 0° into separate portions, the receiver being changed with each rise of 10° in the retort, and the liquid retained in a state of incipient ebullition. In this way a succession of products were obtained; but they were by no means constant; for the portions, for instance, which came over when the fluid was boiling from 160° to 170°, when redistilled, began to boil at 130°, and a part remained which did not rise under 200°. By repeatedly rectifying all these portions, and adding similar products together, I was able to diminish these differences of temperature, and at last bring them more nearly to resemble a series of substances of different volatility.

The next step is significant. Continuing, he says:

During these operations I had occasion to remark, that the boiling point was more constant at, or between 176° and 190° than at any other temperature; large quantities of fluid distilling over without any change in the degree; whilst in other parts of the series it was constantly rising. This induced me to search in the products obtained between these points for some definite substance, and I ultimately succeeded in separating a new compound of carbon and hydrogen, which I may by anticipation distinguish as bi-carburet of hydrogen.

If we substitute for bi-carburet of hydrogen the modern term benzene (introduced by Laurent in 1834), we have in this last sentence the first words announcing the discovery of this fundamental compound.

Faraday next describes his method of separating the bi-carburet of hydrogen from the "rectified products" by freezing it out, particularly from the fraction carefully obtained at 176–190°F.

Different samples of an approximately pure substance were studied, and as a result Faraday summarizes the properties of bi-carburet of hydrogen as follows:

Bi-carburet of hydrogen appears in common circumstances as a colourless transparent liquid, having an odour resembling that of oil gas, and partaking also of that of almonds. Its specific gravity is nearly 0.85 at 60°. When cooled to about 32° it crystallizes, becoming solid; and the portions which are on the sides of the glass exhibit dendritical forms. By leaving tubes containing thin solid films of it in ice-cold water and allowing the temperature to rise slowly, its fusing point was found to be very nearly 42°F.....

It evaporates entirely when exposed to the air. Its boiling point in contact with glass is 186°. The specific gravity of its vapour, corrected to a temperature of 60°, is nearly 40, hydrogen being 1; for 2.3 grains became 3.52 cubic inches of vapour at 212°. Barometer 29.98. Other experiments gave a mean approaching very closely to this result.

Consider this data. Faraday's value for the specific gravity is "nearly 0.85" at 15.5°C. (60°F.). The present value is 0.8850 at 15°C. (Norris).

The melting point given by Faraday is "very nearly" 5.5°C. (42°F.) The present value is 5.483°C. (Norris). Faraday's value for the boiling point is 85.5°C. (186°F.). The present value is 80.4°C. (Norris). Faraday found the vapor density to be "nearly 40" (if H = 1). The present value is 39.024. Recalling that Faraday admitted his compound was not perfectly pure, and allowing for the difference in accuracy between the apparatus used a hundred years ago and that now available, the values of the physical constants obtained by Faraday are remarkably close to those of today.

Faraday also observed that this substance does not conduct electricity, is very slightly soluble in water, and very soluble in fixed and volatile oils, in ether, alcohol, etc.

Faraday's account of the chemical conduct of benzene is profoundly impressive. He noted that it burns with a bright flame and much smoke, forms an explosive mixture with oxygen, gradually deposits carbon and yields carburetted hydrogen gas when passed through a red hot tube, and is inactive toward iodine, potassium, and alkalies.

Regarding the action with chlorine, he says:

> Chlorine introduced to the substance in a retort exerted but little action until placed in sunlight, when dense fumes were formed without the evolution of much heat; and ultimately much muriatic acid was produced, and two other substances, one a solid crystalline body, the other a dense thick fluid. It was found by further examination, that neither of these were soluble in water; that both were soluble in alcohol—the liquid readily, the solid with more difficulty.

The solid was undoubtedly para-dichlorobenzene and the liquid the ortho-isomer, but he did not examine them, merely saying, "I reserve the consideration of these, and of similar compounds, to another opportunity." In this connection we should not overlook the fact that as early as 1821 Faraday had described and analyzed a compound of carbon and chlorine which was subsequently shown (by Hugo Müller) to be hexachlorobenzene (C_6Cl_6); that is, by a curious reversion Faraday had in his hands, so to speak, a chlorine derivative of benzene four years before he discovered benzene itself or studied the action of the two elements upon each other.

Regarding the action with nitric acid and sulfuric acid, he says:

> Nitric acid acted slowly upon the substance and became red, the fluid remaining colourless. When cooled to 32°, the substance became solid and of a fine red colour, which disappeared upon fusion. The odour of the substance with the acid was exceedingly like that of almonds, and it is probable that hydrocyanic acid was formed. When washed with water, it appeared to have undergone little or no change.
>
> Sulphuric acid added to it over mercury exerted a moderate action upon it, little or no heat was evolved, no blackening took place, no sulphurous acid was formed; but the acid became of a light yellow colour, and a portion of a clear colourless fluid floated, which appeared to be a product of the action. When separated, it was found to be bright and clear, but not affected by water or more sulphuric acid, solidifying at about 34°, and being then white, crystalline, and dendritical. The substance was lighter than

water, soluble in alcohol, the solution being precipitated by a small quantity of water, but becoming clear by great excess.

The nitrobenzene was not studied in detail, but the action with sulfuric acid excited Faraday's interest and subsequently was quite fully investigated.

Faraday determined the composition of bi-carburet of hydrogen by two methods, *viz.*, (1) passing the vapor over copper oxide and (2) detonating a mixture of the vapor and oxygen. Regarding the result of the first method he says:

> The following is a result obtained when it was passed in vapour over heated oxide of copper. 0.776 grain of the substance produced 5.6 cubic inches of carbonic acid gas, at a temperature of 60°, and pressure 29.98 inches; and 0.58 grain of water were collected. The 5.6 cubic inches of gas are equivalent to 0.711704 grain of carbon by calculation, and the 0.58 grain of water to 0.064444 of hydrogen.
>
> | | |
> |---|---|
> | Carbon | 0.711704 or 11.44 |
> | Hydrogen | 0.064444 or 1 |
>
> These quantities nearly equal in weight the weight of the substance used; and making the hydrogen 1, the carbon is not far removed from 12, or two proportionals.

He obtained hydrogen 1 and carbon 11.576 as the mean of four other experiments. He explains the "small deficit of carbon" as due to a small proportion of a carbon compound containing less carbon than the bi-carburet and retained during the purification of his analyzed sample of the bi-carburet of hydrogen, and states finally that "the crystalline compound (*i. e.*, the bi-carburet) would, if pure, yield 12 of carbon for each 1 of hydrogen; or two proportionals of the former element and one of the latter, *i. e.*,

2 proportionals	carbon	12	13 bi-carburet of hydrogen."
1	hydrogen	1	

Faraday next gives a full description of the volumetric method as follows:

> This result [2 proportionals of carbon to 1 of hydrogen] is confirmed by such data as I have been able to obtain by detonating the vapour of the substance with oxygen. Thus in one experiment 8092 mercury grain measures of oxygen at 62° had such quantity of the substance introduced into it as would entirely rise in vapour; the volume increased to 8505, hence the vapour amounted to 413 parts, or 1/20.6 of the mixture nearly. Seven volumes of this mixture were detonated in an eudiometer tube by an electric spark, and diminished in consequence nearly to 6.1; these acted upon by potash were further diminished to 4, which were pure oxygen. Hence 3 volumes of mixture had been detonated, of which nearly 0.34 was vapour of the substance, and 2.65 oxygen. The carbonic acid amounted to 2.1 volumes, and must have consumed an equal bulk of oxygen gas; so that 0.55 remain as the quantity of oxygen which has combined with the hydrogen to form water, and which with the 0.34 of vapour nearly make the diminution of 0.9.

He used these figures to show two facts, *viz.*, (1) the composition determined by volume confirms the composition determined by weight, and (2) the vapor density is 39. He goes on to say:

It will be seen at once that the oxygen required for the carbon [2.1] is four times that for the hydrogen [0.55]; and that the whole statement is but little different from the following theoretical one, deduced partly from the former experiments. 1 volume of vapour requires 7.5 volumes of oxygen for its combustion; 6 of the latter combine with carbon to form 6 of carbonic acid, and the 1.5 remaining combine with hydrogen to form water. The hydrogen present therefore in this compound is equivalent to 3 volumes, though condensed into one volume in union with the carbon; and of the latter elements [element] there are present six proportionals, or 36 by weight. A volume therefore of the substance in vapour contains

Carbon.....	$6 \times 6 = 36$
Hydrogen.....	$1 \times 3 = 3$
	39

and its weight or specific gravity will be 39, hydrogen being 1. Other experiments of the same kind gave results according with these. (*Note. This result—carbon 36 and hydrogen 3—gives the same ratio as before, viz., carbon 12 and hydrogen 1.—L. C. N.*)

Faraday concludes with regard to the composition, thus:

With regard to the composition of this substance, my experiments tend to prove it a binary compound of carbon and hydrogen, two proportionals of the former element being united to one of the latter. The absence of oxygen is proved by the inaction of potassium, and the results obtained when passed through a red hot tube.

The results of Faraday's determination of the composition (two proportionals of carbon to one of hydrogen) gave the name bi-carburet of hydrogen and the formula C_2H. But these are not benzene and C_6H_6! The name benzene, as stated above, was not introduced till 1834. Let us consider the formula. At the time Faraday made his discovery (1825) the proportional weight assigned to carbon was 6. If the proportional weight of carbon had been 12 (as it is now), Faraday would have expressed his result as one proportional weight each of carbon and hydrogen, and the formula would have been CH, *i. e.*, what we now designate as the simplest formula. In 1825 the whole subject of atoms and molecules, as well as the relation of atomic weights to molecular weights, was obscure, indeed molecular formulas were unknown. Hence Faraday did not understand the significance of the value 39 he obtained for the vapor density. If he had, he would have written the molecular formula. Translated into modern terms, the value of the vapor density obtained by Faraday—39 to hydrogen 1—becomes 78 on the H_2 basis, and his simplest formula CH gives the molecular formula C_6H_6.

Faraday began the investigation of this oil gas on April 26, 1825, and the actual discovery of benzene may be said to have occurred on May 24th, the day on which he first determined the composition. Hence in one month Faraday isolated benzene from a complex mixture, studied its properties, and determined its composition. Without the slightest reservation we can say that Faraday discovered benzene.

THE STRUCTURE OF MATTER: A BRIEF REVIEW OF PRESENT-DAY CONCEPTIONS. II. THE ATOM AND RADIATION

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This article deals with light radiation and its emission and absorption by atoms and molecules. From studies of such radiation a large part of our present knowledge of the atom has been derived.

The Quantum Theory

Present-day theories of the interaction between atoms and radiation are all based largely on the *quantum theory*. This was first proposed by Planck in 1900 in order to explain the distribution among different wave-lengths of the radiation absorbed or emitted by a black body. Planck's fundamental assumption was that radiant energy is absorbed (or, in a later form of the theory, emitted) only in discrete bundles or *quanta*, each containing an amount of energy equal to Planck's constant, h, times the frequency, ν, of the radiation. (The frequency, ν, is inversely proportional to the wave-length, λ.)

The Bohr Theory of the Hydrogen Atom

Bohr, in 1913, applying Planck's quantum theory to Rutherford's picture of the atom as a miniature solar system, proposed the theory which has served as a foundation for practically all subsequent work in this field.

Considering the neutral hydrogen atom, consisting of one proton and one electron, he postulated:

(1) That the electron is constantly rotating in a circular orbit around the nucleus, *ordinarily without radiating any energy*. (According to classical electromagnetic theory, such a rotating electrical charge would continuously emit radiation and, losing energy in this way, spiral into the nucleus.)

(2) That *only certain orbits are stable*—those in which the angular momentum is equal to an integral multiple of Planck's constant, h, divided by 2π.

(3) That when an electron changes its orbit, radiation is absorbed or emitted having a frequency, ν, determined by the equation:

$$\Delta E = h\nu$$

where ΔE is the difference between the energy of the atom in its final and initial states.

(4) That *when the electron is in one of its stable orbits*, Coulomb's law, giving the force between it and the nucleus, holds as well as the usual centrifugal force law.

Starting with these hypotheses, Bohr was able to calculate *quantitatively*, without the use of any arbitrary constants, the frequencies (and so

the wave-lengths) of all the lines in the normal hydrogen spectrum. Applying the same assumptions to the elucidation of the spectra obtained from the singly ionized helium atom, consisting of nucleus and one electron, quantitative agreement was again obtained. By further assuming elliptical orbits as well as circular, Sommerfeld and others have shown that the theory very satisfactorily accounts for the *fine structures* of the spectrum lines—many of the lines which early observations showed as single lines actually consisting of two or more lines very close together. Moreover, although the application of the theory to more complex atoms, to molecules, to the effect of strong electrical and magnetic fields on spectrum lines, and to other problems has been much more difficult, especially from a mathematical standpoint, the theory has met with success after success in (qualitatively and semi-quantitatively) accounting for experimental results.

This makes it seem almost certain that the mathematical equations developed from the theory are fundamentally correct, and no one has yet offered another picture of the atom which will give these equations.

One of the most recent additions to the Bohr theory, but one which has already received considerable verification, is the idea that the electron, while in rotation about the atomic nucleus, is at the same time spinning, with constant angular momentum, about an axis of its own, much as the earth spins about its axis while rotating about the sun.

The Bohr Theory Applied to More Complex Atoms

The application of the Bohr theory to more complex atoms than hydrogen and ionized helium, although not productive of such precise quantitative checks with experiment, largely because of the mathematical difficulties involved in dealing with a problem of three or more bodies, has enabled physicists to progress very far in the interpretation of atomic spectra and in the study of the distribution of electrons among various "energy levels" in their atoms. Their assignments of electrons to energy levels conform very closely to the assignment to "shells" given in the first paper of this series; in general the spectroscopic evidence is in good agreement with the chemical evidence. Some of the shells, it is true, are further subdivided by physicists, but such subdivisions do not seem to be of much importance chemically.

According to the physicists' picture of these complex atoms the electrons are all in constant orbital rotation about the nucleus.[1] Whether or not this picture will stand the test of time remains to be seen. On the whole, it has so far proved very satisfactory.

[1] Some of the most recent work using the spinning electron theory places some electrons in "orbits" having zero angular momentum. If this is correct, it would seem that these "orbits" must be mere oscillations.

The Bohr Theory Applied to Molecules

The spectrum of light coming from uncombined atoms consists of a few "lines," each produced by light of definite frequency, superimposed on a background of "general" or "white" radiation. From molecules "band spectra" are obtained, each band consisting of a great many lines, spaced in some regular manner and usually close together. The interpretation of band spectra has up to the present been limited almost entirely to simple diatomic molecules.

In interpreting these spectra it is assumed that not only are the motions of the electrons "quantized," but so are the vibrations of the atoms relative to each other and also the rotations of the molecule as a whole. In other words, the molecule can have only certain definite amounts of vibrational energy, of rotational energy, and of kinetic and potential energy due to the electrons in their orbits. When any one or two or all of these change, light is emitted or absorbed, its frequency being determined by the total change in energy:

$$\Delta E = h\nu$$

The spectrum lines in a given band are all said to be due to molecules undergoing the same electronic change (from one energy level to another) and the same change of vibrational energy, but different changes of rotational energy. Different bands in a "band system" result from different changes in vibrational energy; different "band systems" in a "system-series" have their origin in different electron "jumps."

From such spectra it is sometimes possible to determine the moment of inertia of the molecule (and so the distance apart of the atoms), the magnitude of the force holding the atoms together, etc. Those working in this field will probably be able to teach the chemist much in regard to molecular structure and inter-atomic forces in the next few years.

The Nature of Light

It is evident from the foregoing that the problem of the structure of the atom is very closely connected with that of the nature of light. As regards the latter, the present-day physicist finds himself in an apparently hopeless dilemma, and no one knows what will be the way out.

The phenomena of light interference seem absolutely to require light *waves* for their explanation. To take a simple case, light from a source S (Fig. 1), passing through a single slit A, will affect a photographic plate at C; but if there is a similar slit B so placed that the difference between the paths SAC and SBC is one-half wave-length, there will be no effect on the plate at C. Using the wave theory of light the explanation is simple, but it is difficult to see how any other theory, such as one assuming light particles, could account for this phenomenon, for how can the effect of

one particle on a photographic plate be nullified by another particle arriving later?

On the other hand, as has already been mentioned, the distribution of frequencies in the radiation absorbed or emitted by a black body seems to require that radiant energy be either absorbed or emitted by an atom in *quanta*.

Other very definite evidence is furnished by the *photo-electric effect*. If light of a definite frequency is allowed to fall upon a metallic surface, electrons are emitted from that surface, provided the frequency of the light is greater than a certain minimum value, characteristic of the metal, but none at all provided the frequency is less than this minimum. This fact and the relationships experimentally found connecting the frequency and intensity of the incident light with the number and velocities of the emitted electrons seem inexplicable on the basis of a wave theory, but they are in good agreement with the "light dart" theory proposed by Einstein as a further development of Planck's quantum theory.

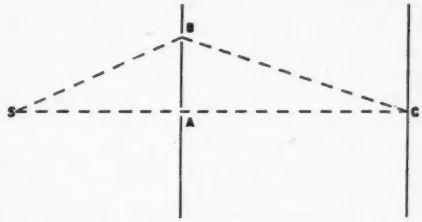

FIG. 1.

Another phenomenon which seems to be impossible of explanation from the standpoint of the wave theory but is in quantitative agreement with Einstein's extreme form of the quantum theory is the *Compton effect*. When light of a frequency ν is allowed to fall upon matter, some of the light scattered has a lower frequency (longer wave-length) than the original.

Such are the problems that physicists are now trying to solve. They are mentioned here chiefly because of the close relationship they bear to the structure of the atom and the molecule and to the mechanism of chemical reactions. Developments of great importance to chemists are sure to come, the writer believes—probably in the very near future—from studies and experiments in this field.

The Radiation Theory of the Mechanism of Chemical Reaction

A few words might appropriately be added here concerning the radiation theory of chemical reaction. It is well known that light radiation is effective in catalyzing many chemical reactions. Some have supposed that light (not necessarily *visible* light, of course) of some particular frequency, or perhaps light having a frequency greater than a certain minimum, is necessary before *any* reaction will go. Whether or not this is the case no one can yet say, but the experimental evidence seems to be quite definitely against the simple theory that for a given reaction only a single frequency

determined by putting the energy change in the reaction equal to $h\nu$, is effective.

Erratum.—Through inadvertence in proof-reading, an error crept into the first article of this series. On page 1111 the mass of the electron is given as 8.999×10^{-28}. The correct value is 8.999×10^{-28}. We acknowledge the kindness of H. Louis Jackson of R. I. State College in calling our attention to this error.

Rare Metal Transmutes Hydrogen into Helium. The metal palladium was the agent that effected the transmutation of hydrogen into helium in the experiment reported by Prof. F. Paneth and Dr. Peters of Berlin University.

Palladium is a rare and heavy metal similar to platinum, and has, in a spongy state, the peculiar property of absorbing a thousand times its volume of hydrogen gas. The hydrogen, when so condensed in the pores of the finely divided metal, is in an unusually active condition, perhaps because the hydrogen, which ordinarily consists of atoms joined together in pairs, is here broken up into separate atoms which then unite eagerly with atoms of other elements such as oxygen. This reaction is so quick that a tiny bit of palladium put into a mixture of hydrogen and oxygen will explode it and form water.

If the conclusions of Paneth and Peters are correct, then the hydrogen atoms condensed by palladium have also the ability to unite with one another in groups of four, which constitute the helium molecules. They passed a stream of hydrogen gas over palladium in the colloidal state in which form the maximum amount of surface is exposed, and after twelve hours of absorption they detected the main lines of the helium spectrum. As longer time elapsed the lines increased in intensity. It would require an enormous length of time to produce a sufficient quantity of helium, to be isolated and analyzed, but by using an extremely delicate spectroscope the amount of helium formed artificially by this process was estimated to be from one to ten thousand millionths of a cubic centimeter.

The transformation of hydrogen into helium, if it can be accomplished, would theoretically involve a loss in weight of eight-tenths of one per cent. The matter so destroyed would be transformed into energy and pass off as rays of light and heat. Such an annihilation of matter would produce an enormous amount of heat. According to some modern astronomers the rays of the sun and stars originate in such decomposition of matter. In the Berlin experiments no evolution of energy was observed, either because the heat was too small to be noticed or because it passed off in the form of radiation of extremely short wave-lengths, like the penetrating rays, coming from the sky, which have been studied by Kohlhoerster and Millikan.—*Science Service*

South American Cinchona May Break Quinine Monopoly. South American countries are being urged to produce their own quinine. Malaria still remains such a problem in the Latin Americas that at the recent Pan-American health conference, a movement to encourage cinchona culture as a public health measure was formulated as a resolution to be put up to the different governments.

Though the cinchona tree, from the bark of which the malaria remedy is made, grows wild in Peru, Bolivia, Ecuador, and Colombia, quinine is almost absolutely under the control of a Dutch East Indies monopoly. This organization regulates the price and output of the essential drug throughout the world. Cultivation of cinchona trees in the countries where they grow naturally would go far, it is thought, toward supplying the native population with more and cheaper quinine.—*Science Service*

AN OUTLINE OF THE DYE INDUSTRY

R. NORRIS SHREVE, CONSULTING CHEMIST, NEW YORK CITY

The importance of dyes in the finer values of life is immediately apparent if we picture to ourselves the utterly drab world we would have if we eliminated them. Truly we use dyes to give color to our world. In the old civilization of the Romans and of the Egyptians when technical advancement was young, the extensive use of dyes was confined to the wealthy and powerful. But nowadays we all enjoy more comforts and pleasures than a Roman Emperor. We all can dress in Tyrian Purple, and we could have the same dye if we did not have better successors to this Tyrian Purple, extracted at great cost from countless shell-fish. But we now make nearly all of our dyes in the chemical factories, though a few of the better and cheaper vegetable dyes have survived.

Raw Materials

We use so many different kinds of dyes, that they are almost as numerous as the different houses in which we live. But analogous to the building of our houses, we synthesize our dyes out of a few crude raw materials. For our houses, we use stone, brick, wood, cement, lime, sand, copper as the primal raw materials. Similar to these we have in the dye industry our crudes, among which we name:

Benzene	Naphthalene
Toluene	Anthracene
Xylene	Carbazole

These we treat with a number of chemicals, as:

Sulfuric Acid	Lime
Nitric Acid	Nascent Hydrogen
Caustic Soda	Chlorine

and from the crudes we construct a number of intermediates. These latter are similar to the different kinds and fabrications of stone, clay, wood, and metals that enter into our houses. And to make the finished dye we unite the intermediates together into a more or less complex individual dye, just as we build up a house out of bricks, boards, window sash, copper gutters, and plaster.

Intermediates

In the United States we produce out of less than ten crudes, some three hundred and twenty-five intermediate products of which those of the greatest use and importance are:

Acetyl-*p*-toluidine
1-Amino-2-naphthol-4-sulfonic acid

1-Amino-8-naphthol-3:6-disulfonic acid (H acid)
2-Amino-5-naphthol-7-sulfonic acid (J acid)
2-Amino-8-naphthol-6-sulfonic acid (Gamma acid)
Aniline hydrochloride
Aniline oil
Anthraquinone
Benzaldehyde
Benzidine
Benzoic acid
Benzyl chloride
Chloro-benzene
Diamino-stilbene-disulfonic acid
Dimethyl-aniline
Dinitro-benzene
Dinitro-chloro-benzene
Dinitro-toluene
Ethyl-benzyl-aniline
Metanilic acid
α-Naphthol
β-Naphthol
1-Naphthol-4-sulfonic acid (Nevile and Winther's Acid)
1-Naphthol-5-sulfonic acid
2-Naphthol-3:6-disulfonic acid
2-Naphthol-6:8-disulfonic acid
α-Naphthylamine
β-Naphthylamine
1-Naphthylamine-4-sulfonic acid (naphthionic acid)
1-Naphthylamine-5-sulfonic acid (Laurent's Acid)
1-Naphthylamine-6-and-7-sulfonic acids (Cleve's Acid)
1-Naphthylamine-8-sulfonic acid
1-Naphthylamine-4:8-disulfonic acid
1-Naphthylamine-3:6:8-trisulfonic acid
2-Naphthylamine-1-sulfonic acid
2-Naphthylamine-5:7-disulfonic acid
2-Naphthylamine-6:8-disulfonic acid
p-Nitro-aniline
o-Nitro-anisole
Nitro-benzene
Nitro-toluene
o-Nitro-toluene
p-Nitro-toluene
p-Nitro-toluene-*o*-sulfonic acid
m-Nitro-*p*-toluidine
Nitro-xylene
Phenol
Phenyl-1-naphthylamine-8-sulfonic acid
m-Phenylene-diamine
p-Phenylene-diamine
Phenyl-hydrazine-*p*-sulfonic acid
Phthalic acid and anhydride
Salicylic acid

Sulfanilic acid
Toluidine
o-Toluidine
p-Toluidine
m-Tolylene-diamine
Xylidine

Every intermediate in the above list is made here to the extent of 50 tons or more each year. The largest productions were 20,000 tons for nitrobenzene, the greater part of which was made into aniline. An interesting American use for aniline and, more particularly, some of its derivations is for accelerators in the vulcanization of rubber, and this use for aniline even now is fast equalling, if it has not already exceeded, the tonnage used for the "aniline dyes." We might speak of our rubber tires as "aniline tires" so greatly has this intermediate influenced the rubber industry.

Dyes

The dyes themselves are made by combining intermediates, or subjecting them to oxidation, nitration, sulfonation, and the like. Sometimes one single intermediate by oxidation, for example, reacts with itself to form a dye. This is true of *p*-phenylene-diamine which makes a black fur dye, known as Ursol and it is also true of aniline itself which furnishes the important Aniline Black.

Generally the reactions are more complex. But the most common is that giving the azo dyes, wherein an amine is diazotized with nitrous acid and then united, for example, with a phenol or a naphthol. Numerous and varied indeed are the progeny of this diazotization reaction and combination. Hundreds of such dyes are employed throughout the world for all sorts of applications.

Chemical Classification of Dyes

Dyes from a chemist's point of view are classified largely by the chemical structure. On the other hand the dyer or user arranges dyes in his mind according to the way they work. One system is scientific, the other pragmatic. Both systems are important and are employed very generally in practice. The manufacturer deals with both, as he must not only make dyes by chemical reactions but he must sell them to the user according to their properties and how they act when invited out in company with cotton, silk, wool, wood, and rayon.

First we have to make the dyes before we can use them so let's give the chemist his inning at the bat before we call in the dyer. Here we find that the arrangement of atoms and groups of atoms predominate in directing the viewpoint. This classification is that of the chemist, whether a research worker, teacher, or manufacturer.

TABLE I

CHEMICAL CLASSIFICATION AND NUMBER OF DIFFERENT DYES IN COMMERCE IN U.S.

Dye class according to chemical structure	Number of members listed in the "Colour Index"	Number of members entering into commerce in the U. S.	
		By domestic manufacture	By Import (excluding those also manufactured in U. S.)
Nitroso	6	1	...
Nitro	8	2	1
Azo	605	193	42
Azo, but not classified in "Colour Index"	...	113	241
Stilbene	16	3	...
Pyrazolone	19	4	1
Ketonimine	2	1	1
Triphenylmethane and diphenylnaphthylmethane	82	28	20
Xanthene	46	10	10
Acridine	15	1	4
Quinoline	12	3	2
Thiazole	6	4	...
Indamine	3	...	...
Indophenol	3	...	...
Azine	46	10	6
Aniline black and the like	6	3	...
Oxazine	44	5	9
Thiazine	13	3	2
Sulfide	80	12	36
Hydroxyketone, etc.	14	...	1
Anthraquinone	67	10	22
Anthraquinone vat	82	14	104
Arylidoquinone vat	1	...	...
Indigoid	54	5	25
Unclassified synthetic dyes	...	51	68
Natural organic dyes	19	5	2
	1249	481	597

I would not call this table a wholly consistent arrangement, as it is based on two principles, one, that of the radicals which impart color to the molecules—the so-called chromophoric groups—and the other that of the parent intermediate of the groups. Yet it is an excellent grouping, as practice has shown.

The table summarizes in one column the number of members of the given classes as listed in the "Colour Index" of the Society of Dyers and Colourists, and the other columns the number of individuals that enter into commerce in the United States, either by direct manufacture or by import from abroad. As the dyes under the import column are only those not made also in the U. S., we find the total individual dyes by uniting the sums of the last two columns giving us almost eleven hundred individuals. This is certainly a varied industry! Lest a wrong impression be gained let it

be emphasized that though the number of imported dyes is large the tonnage is relatively small, being only 5 per cent of the total tonnage. As a matter of fact we now manufacture 95 per cent of our own dyes.

Research

This is truly a remarkable accomplishment when, in the short space of a decade, the Americans have reversed the scales from the time when they made only a few per cent of their dyes, where they only import a few per cent. This accomplishment was made possible by persistent and systematic research work ably supported by far-seeing business men and applied by skilled chemical engineers. This has all been and still is very costly, amounting at present to over $2,000,000 a year and averaging much higher throughout that period, probably totaling more than $30,000,000 for the decade.

Another hopeful sign of the times is that this research is continuing and that the American dye makers are beginning to bring out new dyes—in other words, they are progressing. The tendency is to produce better dyes that can be applied by less costly dyeing methods.

Classification of Dyes by Application

In ordinary commerce, dyes are mostly spoken of according to method of application, and this is right, as there is no sense in manufacturing a dye if it cannot be used. Classification by this method also strikingly exhibits the varied functions dyes are called upon to play in our everyday life.

TABLE II

CLASSES OF APPLICATION OF DYES

Acid Dyes	Color Lake Dyes
Basic Dyes	Spirit Soluble Dyes
Direct Cotton or Substantive Dyes	Food Dyes
Developed Dyes	Photographic Dyes
Mordant and Chrome Dyes	Medicinal Dyes and Bacteriological Stains
Sulfur Dyes	Indicator Dyes
Vat Dyes	

Chemical structure has, in the final analysis, everything to do with the way dyes function and hence their application. But the classification by use does not parallel that by structure as given in Table I.

Azo dyes belong to a number of application classes as some azo dyes are basic in their dyeing properties; others are acid or direct or spirit-soluble. This is also true of other of the chemical classifications. Furthermore, as a rule, a given intermediate does not produce colors of the same application. However, there are a few general tendencies; for example, nearly all benzidine or H-acid dyes are so-called direct dyes, and anthraquinone dyes are either mordant or vat dyes.

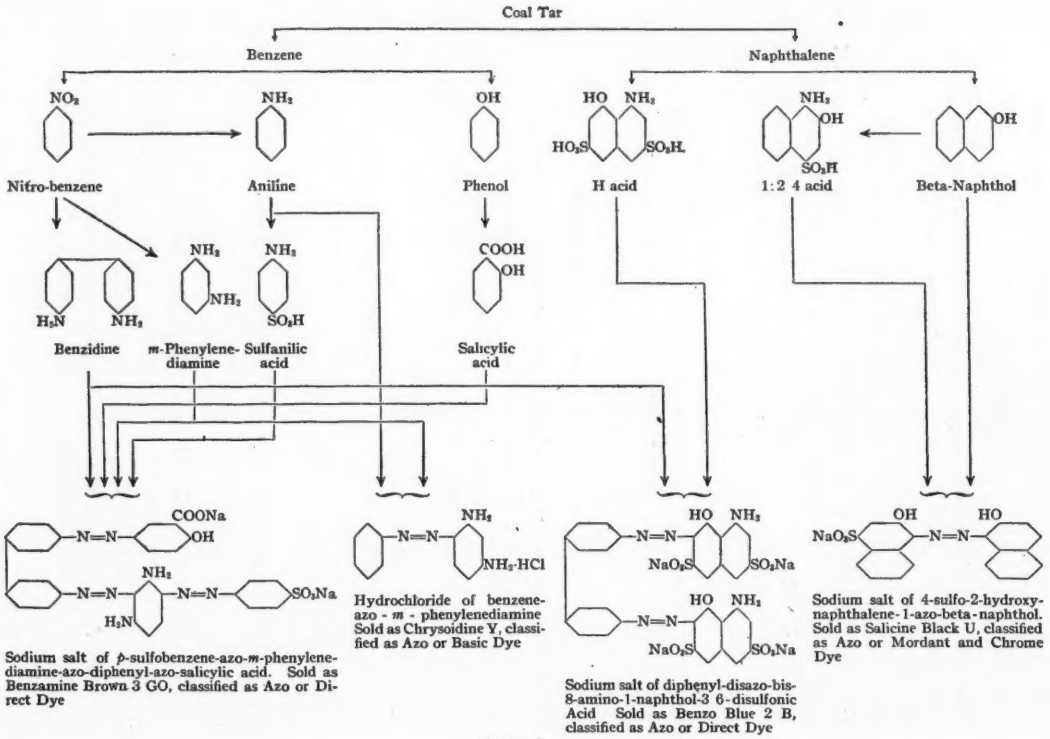
Coal Tar
Benzene
Naphthalene
Nitro-benzene
Aniline
Phenol
H acid
1:2 4 acid
Beta-Naphthol
Benzidine
m-Phenylene-diamine
Sulfanilic acid
Salicylic acid
Sodium salt of p-sulfobenzene-azo-m-phenylene-diamine-azo-diphenyl-azo-salicylic acid. Sold as Benzamine Brown 3 GO, classified as Azo or Direct Dye
Hydrochloride of benzene-azo - m - phenylenediamine Sold as Chrysoidine Y, classified as Azo or Basic Dye
Sodium salt of diphenyl-disazo-bis-8-amino-1-naphthol-3 6-disulfonic Acid Sold as Benzo Blue 2 B, classified as Azo or Direct Dye
Sodium salt of 4-sulfo-2-hydroxy-naphthalene-1-azo-beta-naphthol. Sold as Salicine Black U, classified as Azo or Mordant and Chrome Dye

FIGURE 1

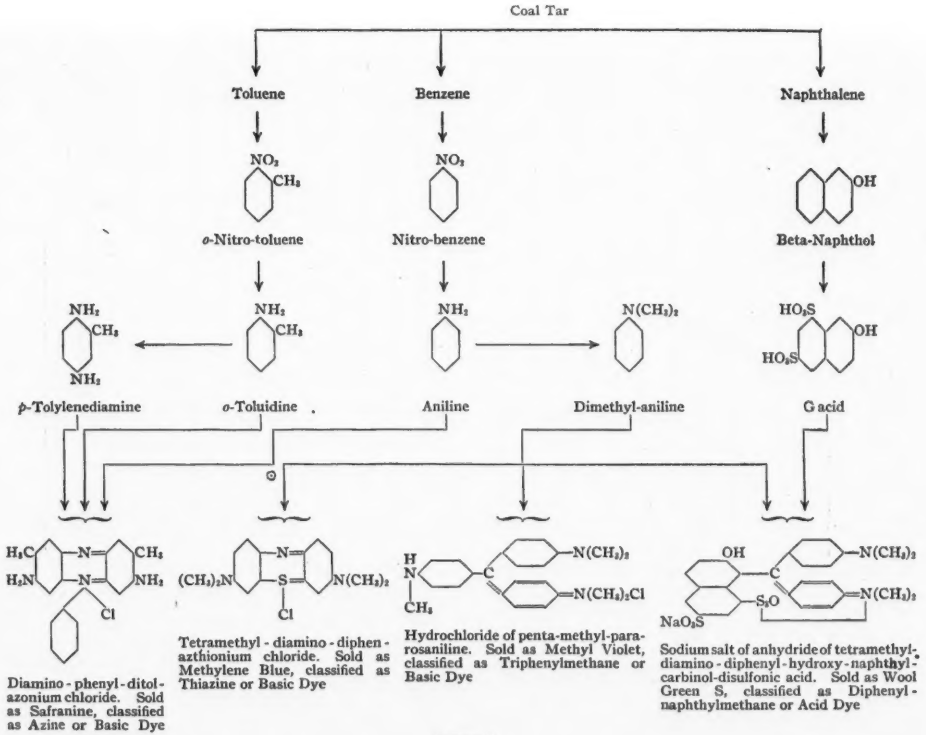
Coal Tar
Toluene
Benzene
Naphthalene
o-Nitro-toluene
Nitro-benzene
Beta-Naphthol
p-Tolylenediamine
o-Toluidine
Aniline
Dimethyl-aniline
G acid
Diamino - phenyl - ditol - azonium chloride. Sold as Safranine, classified as Azine or Basic Dye
Tetramethyl - diamino - diphen - azthionium chloride. Sold as Methylene Blue, classified as Thiazine or Basic Dye
Hydrochloride of penta-methyl-para-rosaniline. Sold as Methyl Violet, classified as Triphenylmethane or Basic Dye
Sodium salt of anhydride of tetramethyl-diamino - diphenyl - hydroxy - naphthyl - carbinol-disulfonic acid. Sold as Wool Green S, classified as Diphenyl - naphthylmethane or Acid Dye

FIGURE 2

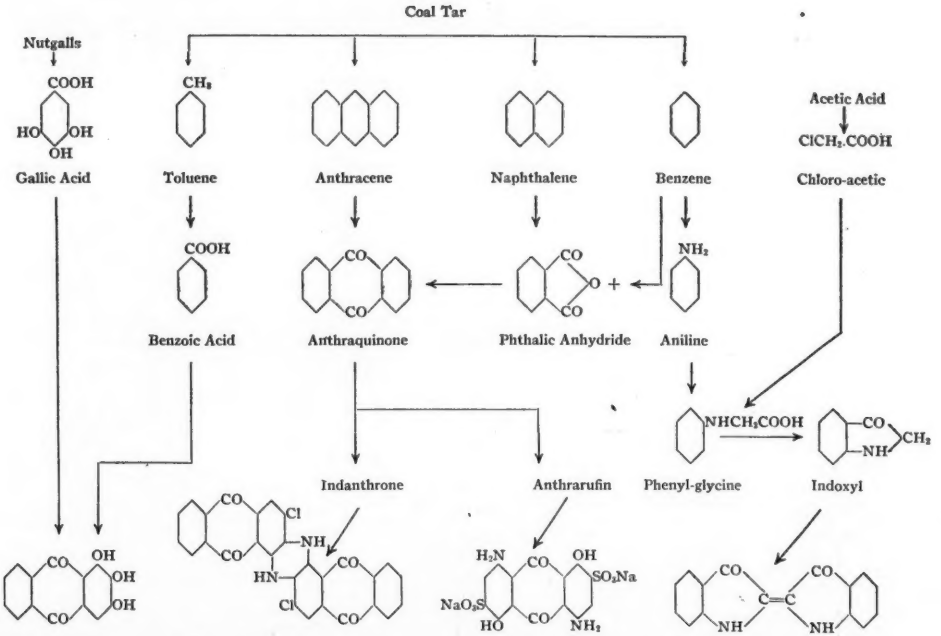
Coal Tar
Nutgalls
COOH
HO
OH
OH
Gallic Acid
CH3
Toluene
Anthracene
Naphthalene
Benzene
Acetic Acid
ClCH2COOH
Chloro-acetic
COOH
Benzoic Acid
CO
CO
Anthraquinone
CO
O +
CO
Phthalic Anhydride
NH2
Aniline
NHCH2COOH
Phenyl-glycine
CO
NH
CH2
Indoxyl
Indanthrone
Anthrarufin
OH
OH
OH
CO
CO
1:2:3-Trihydroxy-anthraquinone. Sold as Alizarine Brown, classified as Anthraquinone Dye or Mordant Dye
Cl
NH
HN
Cl
3:3'-Dichloro-N-dihydro-1:2:1':-2'-anthraquinoneazine. Sold as Indanthrene Blue GCD, classified as Anthraquinone Vat Dye or Vat Dye
H2N
NaO3S
SO3Na
HO
NH2
Sodium salt of 4:8-Diamino-1:5-dihydroxy-anthraquinone-2·6-disulfonic acid. Sold as Alizarine Saphirol B, classified as Anthraquinone Dye or Mordant Dye
C=C
NH
2.2'-Bis-indole-indigo. Sold as Indigo, classified as Indigoid or Vat Dye

FIGURE 3

The inter-relationship of the intermediates is shown in the Figures 1, 2, and 3, depicting the structural forms of dyes and the intermediates from which they originate.

Description of Dye Application Classes

Acid Dyes.—The acid dyes are quite generally sodium salts of sulfonic or carboxylic acids of the parent dye molecule, or a nitro compound. They are mostly used in an acid bath in which the wool or silk is immersed, and are particularly used for the dyeing of woolen hosiery, carpet yarns, suiting, dress goods, and hat materials. Silk is often dyed by these colors, but cotton practically never.

This class of dyes is a large one and includes many important dyes from picric acid, through most of the azo class, to the eosines and members in the triphenylmethane and anthraquinone series.

Basic Dyes.—These are mostly salts of dye bases with hydrochloric acid and include a large number of triphenylmethane dyes and some azines, azos, thiazoles, thiazines, and acridines.

The basic dyes have a direct affinity for wool and silk but are fixed on cotton by means of tannin. They are not as important for the textile fibers as formerly, being displaced by dyes of greater fastness or easier application. They are, however, still used very extensively in the tinting of paper and manufacture of lithographic inks, typewriter ribbons, "carbon" paper, and pencils. Here we find Methyl Violet, Methylene Blue, and Malachite Green.

Direct Cotton Dyes.—These are mostly derivatives of benzidine, toluidine and dianisidine in the azo class. The important thiazole dyes also dye direct. They are absorbed on the cotton or other vegetable fibers "directly" from a salt or alkaline bath.

This class is a very large and important one, and includes such well-known dyes as Direct Black EW, Benzamine Brown 3GO, Oxamine Black BHN, Chrysophenine G, and Diamine Fast Red F.

Developed Dyes.—These colors are insoluble and must be made right on or in the fiber or other substance to be dyed. Because of their insolubility they are faster to washing than many of the direct dyes which they resemble in their chemical structure. Many are azo dyes like Zambesi Black and Para Red. Aniline Black is also a developed color. Here it may be said that the chemist makes his laboratory right in the cotton fiber and carries on his reactions there.

Mordant and Chrome Dyes.—This dye application class is often split up into subdivisions such as after-chrome, meta-chrome, acid chrome, and the like. The members are those which require a metallic mordant to fix the dye on the fiber. The mordants used are salts of chromium, aluminum, iron, and tin.

The mordant dyes are very fast and are much used on wool and for cotton

printing. Alizarine is an important member of this application group, to which Salicine Black U, Alizarine Saphirol B, and Diamine Black also belong. Mordant dyes occur among members of the anthraquinone, azo, oxazine, and triphenylmethane classes.

Sulfur Dyes.—These colors are applied in a sodium sulfide solution chiefly for dyeing of cotton uniform clothes, hosiery, and yarns. These dyes are a large and important class from the standpoint of tonnage used. Chemically their structure is often indefinite and the number of members of the class is not large in comparison to the pounds used. They contain sulfur as a part of their molecular structure. The sulfur dyes are not bright and brilliant; they produce the heavy, deep shades of black, brown, green, and blue.

Vat Dyes.—These dyes are very inert chemically and are first fixed on the fiber in a reduced state, and then oxidized to the dye itself. They are of great and increasing importance because of their exceptional fastness to light, washing, acids, alkalies, and in many cases to bleaching agents. They, furthermore, are to be found in beautiful and varied shades, and are much used on dyed and printed cotton fabrics such as shirtings, ginghams, muslins, blouse materials, and dress goods. They are used to a slight extent for silk and wool.

Except for Indigo these dyes are costly, as they are complicated and must go through many steps in the process of manufacture. They include the chemical classes of Indigoid and Anthraquinone Vat dyes.

Color Lake Dyes.—These include the pigment or paint dyes and consist of a carrier or precipitating agent to which the dye is fixed. Such carriers are barium or lead salts, aluminum hydroxide, china clay, or barytes. The dyes employed are from the acid, basic, or mordant classes. Sometimes the dye is made right on the carrier as, for example, Para Red from diazotized *p*-nitroaniline and *β*-naphthol. These color lakes are filtered, washed, dried, and ground. They are employed as pigments in paints, inks, artists' colors, wallpaper, and in rubber.

Spirit Soluble Dyes.—Such coloring matters are those soluble in alcohol, benzene, oils, and the like, and which find application in the coloring of stains, varnishes, waxes, and gasoline.

Food Dyes.—These are a few dyes which can be used in foods without any harmful effects. To make this doubly sure, the Bureau of Chemistry will actually certify to the harmlessness of the dyes by a test on a sample representing the actual manufactured batch. This gives rise to the "certified food dyes." There are only a dozen such colors, among which are Amaranth and Tartrazine. These are mostly acid dyes which are specially purified. They are employed in coloring a large number of foods such as dairy products, liquors, jellies, chocolates, candies, confections, soft drinks, fruits, and canned goods.

Photographic Dyes.—Several dyes are employed to sensitize the ordinary photographic emulsion to red rays, or in other words, to make the light sensitiveness of the film more similar to that of the eye. The two dyes most used for this purpose are Orthochrome T and Pinacyanole, both belonging to the Quinoline class of dyes in our chemical arrangement.

Medicinal Dyes and Bacteriological Stains.—This is an important and growing field, largely for the reason that dyes have specific properties in relation to organic parts and functions. Methylene Blue and Phenolphthalein have such particular physiological effects, others such as Acriflavine, specific antiseptic action. The localized action of the bacteriological stains has long been taken advantage of in the study of unicellular organisms. Referring particularly to the bacteriological stains, prior to the war we imported practically all such stains, now we make them here. This accomplishment is one which required profound study both from the manufacturing and the application aspects.

Indicator Dyes.—With the recognition of the influence of minor variations in H-ion concentration on a great many equilibriums and reactions, particularly those involving life processes, the use of dyes to determine such H-ion concentrations has grown. This combined with the long established indicator use of such dyes as litmus, phenolphthalein, methyl orange and Congo red, places these dyes in a very important position in the control and study of chemical reactions.

The Inter-relationship of the Dyes

There is no field of chemistry in which there is such a marked inter-relationship of the various members. This has become apparent as we studied the use of dyes, when we found a given individual used in widely different fields. It is more apparent from an inspection of the chemical structure. Only a few crudes give rise to hundreds of intermediates and the intermediates combine to furnish literally hosts of dyes—most of which are, to be sure, not commercially used.

A given intermediate will go to form widely related dyes. Figures 1, 2, and 3 give the derivation of a few typical dyes of a number of different classes, both chemical and application. It is seen that aniline, for example, enters into the making of a number of the dyes depicted. This community of intermediates would be even more striking had there been space to illustrate the structural relationship of more dyes.

The figures do show, however, that a few crudes give a number of intermediates which branch out into all kinds and conditions of dyes. This charting is purposely made one of structure to illustrate some of the chemistry involved in the constitution of dyes. Dyes hailing from coal as a parent substance go out and touch our life in all its ramifications. There is nothing so typical of our present civilization with its fabrication of simple

to complex as the dye industry. It literally lies next our skin in the clothes we wear. Its products are always before our eyes, in the ink with which we write, in the stains on our furniture, in the dye on our rugs. This industry, furthermore, helps to keep us well and to heal us when we are ill; its by-products are means of national defense. It is literally an essential industry.

REFERENCES FOR FURTHER INFORMATION

F. M. Rowe, "Colour Index." Here practically all commercial dyes are arranged in tabular form. Methods of preparation and properties are given in detail.

Georgievics and Grandmougin, "A Text Book of Dye Chemistry." This is the best one-volume book on chemistry of dyes.

J. C. Cain, "Intermediate Products for Dyes." Intermediates are well described.

R. Norris Shreve, "Dyes Classified by Intermediates." A reference book for relation of dyes to intermediates.

Tells How Drugs Poison Bacteria. The synthetic drugs of modern chemotherapeutics act as "shock troops," and the antitoxins which they induce the body to form are the "mopping-up squads" in the battle against invading bacteria.

This, broadly stated, is the kernel of the theory of the action of such products of the dyestuffs laboratory as salvarsan and Bayer 205 advanced by Dr. Wilhelm Roehl, expert of the Elberfelder Farbwerke. "The first action of chemotherapeutic substances," he said, "is directly upon the germs themselves, poisoning them. The autonomic production of antitoxins by the body, which the drugs induce, is of secondary importance but valuable for the final destruction of the bacteria previously damaged by the chemotherapeutics."

The theory of the chemical action of synthetic drugs containing arsenic advanced by Dr. Paul Ehrlich, the inventor of salvarsan, best known of such arsenicals, was discussed by the assembled scientists. Though such drugs are of extremely complex chemical structure, their final action on disease germs, according to Dr. Ehrlich's view is similar to that of the common arsenic used in rough-on-rats or in the too-popular, present-day murder mysteries. The famous German scientist holds that the complicated organic arsenic compounds act by the reduction of the arsenic acid group they contain to arsenic oxide. He also holds that organic drugs containing antimony, vanadium, bismuth, mercury, silver, gold, and platinum act in a similar manner.—*Science Service*

Rubber Behaves Like Crystal When Stretched. Why does a rubber band stretch, and what happens when it does? This is the question that Dr. Paul Katz of the University of Amsterdam asked himself, and partially answered at the recent meeting of the Association of German Natural Scientists and Physicians at Düsseldorf.

The puzzling thing to scientists about the stretching of a rubber band is how it can stretch so much, even twelve times its original length, without breaking, when the molecules of which it is made must be so widely separated. Dr. Katz used the X-ray spectrograph, an apparatus by which it is possible to take photographs which reveal the actual arrangement of the molecules and the distances between them.

Ordinarily, the X-ray spectrograph only works with substances that are in the form of crystals. Rubber is not crystalline, but amorphous. However, Dr. Katz tried it and has found that when the rubber is stretched, the photograph shows that it behaves just as if it were crystalline, and returns to the amorphous form when collapsed. So far he has been unable to explain why this should occur.—*Science Service*

STUDENT PRECISION IN QUANTITATIVE ANALYSIS.* I. FACTORS INFLUENCING PRECISION

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The fair evaluation of the student's laboratory work in quantitative analysis is a difficult problem for which no satisfactory solution has as yet been offered. The objective in requiring the student to carry out certain analyses is not only to illustrate principles and develop careful technic, but also to emphasize accuracy and integrity in reporting results. While a few text-books on the subject specify limits of precision for certain of the common determinations, no systematic study of actual student results appears to have been made. Without a knowledge of the limits to which a student can be held, any basis one might devise to evaluate his analytical work is likely to be somewhat arbitrary and involve largely the personal equation of the instructor. If too high a degree of precision is demanded of the beginner, it is both discouraging to him, and, as Professor Mahin[1] points out, is seriously demoralizing in that "it encourages the falsification of analytical records." To ascertain what the student is capable of doing with the accepted methods, the writers have made a study of students' results in gravimetric and volumetric analysis obtained over a period of years. It is the purpose of the present paper to discuss briefly the factors which influence student precision. In a later paper we shall develop the limits of precision for certain determinations commonly included in courses on the subject.

Classification of Factors

The factors to be discussed may, for convenience, be divided into three classes: (*a*) Those over which the instructor has some control and for which he is responsible; (*b*) those which are due to inherent peculiarities of method as well as of apparatus employed and which limit the accuracy attainable by the student; and (*c*) those factors which are a function of the mental make-up of the student and determine his ability in analytical work; namely, skill, judgment, and integrity. We might also consider the first group under (*a*) as constant factors which the instructor can definitely fix, whereas the latter two groups (*b*) and (*c*) may be variable depending upon how the student uses the methods and apparatus.

Factors for Which the Instructor Is Responsible

Of those factors which the instructor can in some measure control or fix, the *purity of reagents* deserves first mention. As has been adequately

* A revision and expansion of a paper delivered before the Division of Chemical Education of the A. C. S. at Tulsa, April 6, 1926, under the title, "Limits of Student Precision in Elementary Quantitative Analysis."

[1] Mahin, *Science*, **68**, 320 (1923).

pointed out by Fales,[2] chemicals of the highest purity as obtained from supply houses may contain prohibitive amounts of impurities. These may be either in the form of the actual constituent to be determined or of some substance which reacts similarly. To insure accurate results, either the pure reagent or carefully analyzed materials must be used, and in such quantities that correction for any impurities present may be made if necessary, as is done in the determination of nitrogen by Kjeldahl's method and of silica in an insoluble silicate. It is highly desirable to encourage the student to be at all times critical of his reagents, not only because there is a natural tendency to assume reagents to be pure, but also because he will be expected to work independently and assume responsibility for the purity of his reagents when he enters the commercial field. The authors have even gone so far as to require the student to make a preliminary test[3] of his reagents before beginning a given determination, to reassure himself of the absence of interfering elements. Contamination may sometimes occur through no fault of the laboratory staff.

A second factor is the *purity of standards* used in volumetric analysis. To serve as a trustworthy standard, a substance should be pure (or of known purity), stable to air and moisture, of definite and constant composition containing no water of crystallization, of high molecular weight, soluble in water, preferably colorless and producing no colored compounds, and capable of direct titration. It is also very desirable that the standard contain less than 100% of reacting constituent, so that slight non-uniformity of sample as well as error in weighing may be compensated for by the use of a relatively larger sample.

In our study of student analyses, certain of the existing standards have been examined critically, both as to their reliability and convenience for student use. The reliability of sodium or potassium chlorides as standards for silver nitrate requires no comment. For acidimetry, the compounds commonly mentioned in elementary text-books are sodium and calcium carbonates, crystallized oxalic acid, benzoic acid, and others. Sodium and calcium carbonates are almost invariably mentioned, the majority of authors apparently favoring sodium carbonate. Calcium carbonate, however, is preferred by the present writers, since it can be precipitated, washed, and dried without decomposition. In the preparation of pure sodium carbonate, there is admittedly some danger of non-uniformity of sample due to hydrolysis as the last traces of moisture are removed at 300°C. Although calcium carbonate requires a residual titration, the

[2] Fales, "Inorganic Quantitative Analysis," p. 25, 1925, Century Co., New York.

[3] Just recently a student experienced trouble in his sulfur determination, which was traced in short time to presence of sulfuric acid in the hydrochloric acid he used. In another case, a limestone yielded more insoluble gangue than the original weight of sample. Examination of the precipitate showed presence of calcium sulfate, which was traced to sulfuric acid in the nitric acid used in dissolving.

experience of the writers has shown that it gives reproducible results in the hands of the beginner.

The well-known standards for potassium dichromate and permanganate, still prescribed in some texts, such as iron wire,[4,5,6] and ferrous ammonium sulfate,[7,8] have not been found trustworthy. For permanganate solutions, sodium oxalate which is commonly conceded by authors to be trustworthy, has been found infallible as a standard, provided its uniformity is assured and purity checked against a Bureau of Standards sample. Departing from the orthodox standards for dichromate, the authors recommend a uniformly mixed and dried hematite ore, whose purity has been checked against a reliable standard such as Sibley Iron Ore No. 27, of the Bureau of Standards. Such a substance is conducive to accuracy also, because both standardization of solution and final titration of iron in ore are made under exactly the same conditions.

As an iodometric standard, copper wire or foil, iodine, and arsenious oxide are recommended by various authors. Copper foil[2,4,7] as a student standard is found by the writers to be unreliable because of non-uniformity. A number of analyses on the purest copper foil obtainable have shown it to vary by as much as 0.2% from sample to sample when determined electrolytically, even though thoroughly cleaned to remove tarnish. Resublimed iodine when weighed into a flask containing potassium iodide solution constitutes a satisfactory procedure according to Fales[9] and Olsen,[10] though from the experience of the writers it appears preferable to weigh a known volume of sodium thiosulfate solution in a 60 cc. g. s. flask, adding iodine in slight excess, and reweighing. The excess of iodine is then titrated and any loss of iodine by vaporization is prevented. Arsenious oxide for student use has proved most satisfactory, which bears out the experience of the authors[8] above referred to. Summing up our observations, since unreliable standards may alone vitiate all painstaking effort on the part of the student, it is essential that the student be furnished standards of unquestionable purity, if his results are to have any significance.

A third factor is that of *uniformity of unknown samples*. Lack of agreement of duplicate determinations carried out by an ever so critical student might easily occur if the sample were "spotted." Various precautions must be observed in the preparation of unknown samples. Ridsdale and Ridsdale[11] have made a study of samples of commercial materials, which might

[4] Talbot, "Quantitative Chemical Analysis," 6th ed., Macmillan, p. 66.
[5] Smith, "Quantitative Analysis," 1921, Macmillan, p. 126.
[6] Foulk, "Notes on Quantitative Chemical Analysis," 1920, McGraw-Hill, p. 168.
[7] Mahin, "Quantitative Analysis," 3rd ed., 1924, McGraw-Hill, p. 226.
[8] Blasdale, "Principles of Quantitative Analysis," 1921, Van Nostrand, p. 339.
[9] Fales, Ref. 2, p. 357.
[10] Olsen, "Quantitative Chemical Analysis," Van Nostrand, p. 325.
[11] Ridsdale and Ridsdale, *J. Soc. Chem. Ind.*, 38, 15T (1919).

serve not only as precision standards in chemical analysis, but also as a basis for reference for the benefit of buyer and seller of products on a commercial scale. They discuss numerous aspects of the preparation of such samples to afford the necessary uniformity. Certain samples contaminated with oils, such as metal turnings, flotation concentrates, etc., should be washed with suitable solvents and dried without chance of surface oxidation. Silicate rock samples containing constituents of varying hardness should be pulverized as a whole, rather than sifted in the course of grinding. Samples containing water of crystallization should preferably be avoided. If uniformity of samples cannot be assured when supplied in solid form, it becomes desirable to give them to students in the form of solutions; for example, commercial alkalies or cyanides. In any case, commercial products seem preferable to pure chemicals as student samples because (1) the determinations are then carried out in the presence of such elements as are met with in practice, and (2) the results in the analysis of such products cannot easily be forged by the student.

Finally, an all-important factor is the *precision with which the true percentage of desired constituent is known.* This constitutes the basis upon which calculations of departure and percentage error are made, upon which, in turn, the student's work is graded. It appears desirable to prepare and maintain only a limited number of very accurately analyzed samples for student analysis rather than a wide variety chosen at random, whose composition has not been positively established. If the number is small, frequent check analyses can be made. It is always gratifying to the student to be informed that he has closely approached the "theoretical" value especially if the instructor can render the verdict with confidence and assurance.

Factors Involving Method and Apparatus Employed

All quantitative methods possess certain limitations as to their accuracy because all precipitates are somewhat soluble, absolutely pure precipitates are rarely obtained and true end-points never exactly realized in practice. However, the errors inherent in the quantitative method should be very nearly fixed if the specified conditions are rigorously observed. The ability of the student is measured in part by the extent to which he can approach the ideal set of conditions. A student seeking to attain the maximum precision obtainable in any analysis would have to concentrate his attention upon his work at all times, watch closely the sources of error and consider the effect of interfering elements.

The apparatus employed by the student also contributes in greater or lesser measure to the errors in analysis. Stott[12] has made a quantitative study of the effect of apparatus errors on the accuracy of volumetric analyses. Considering in each case the errors arising from the use of flasks,

[12] Stott, *J. Soc. Chem. Ind.*, **40**, 63T (1921).

burettes, uncertainty of end-points, temperature changes, and chemical errors such as partial oxidation, he estimates the minimum probable percentage error to be 0.4%, assuming the errors to be cumulative and not compensating. On the average, the student may be expected to make an error of this magnitude, even if he takes every other possible precaution against error. In the hands of the beginner, the precision will vary in proportion as he guards against conditions which vitiate their accuracy.

Factors Involving Skill, Judgment, and Integrity of Student

While the factors relating to method and apparatus involve in large measure the student's ability, we shall here refer to his mental attitude toward the work of the course. Manipulative skill is important because quantitative analysis is a course in technic. Accurate results are out of the question unless the operations of weighing, measuring of liquids, precipitations, washing, and ignition are carried out with the greatest care. Much must necessarily be left to the judgment of the student in carrying out the details of a process, such as choice of size of sample, volume of reagent to employ, how long to digest a precipitate, whether or not a precipitate has been washed free from chlorides, etc.

The *integrity* of the student in quantitative analysis, as Talbot[13] has very forcefully expressed it, is of paramount importance in all quantitative work, and deserves more than casual mention here. While the average instructor perhaps regards all students as perfectly honest, the fact remains that a certain percentage of them will resort to dishonest methods to obtain a good grade or to avoid repeating an analysis. The forging of analytical results is one of the most serious problems with which the instructor in the subject must deal, chiefly because it is difficult to prove deliberate dishonesty from the results alone. To meet this problem, the writers have found it desirable to require the student to submit crucibles containing precipitates for inspection by the instructor before the analysis is graded and accepted. This device has two advantages: (1) It enables forgery to be detected with almost absolute certainty, because in case of doubt, the instructor can examine *or weigh* the crucibles himself. Several cases of dishonest work have been detected in this way. (2) It affords a valuable opportunity to correct certain errors in an analysis which could not be accounted for otherwise, such as reduction of an ignited barium-sulfate precipitate to sulfide, proved by adding phenolphthalein. Falsification of data can further be minimized by requiring the student to record all data in ink and in final form in his note-book at the time they are obtained. The writers have found it necessary to check all arithmetical work to locate both deliberate and accidental discrepancies. Paradoxical as it may seem,

[13] Talbot, Ref. 4, Introduction, p. 2.

and simple as all quantitative calculations are, students make an appalling number of arithmetical blunders, which deserve to be penalized heavily. Such penalties exert a wholesome influence by developing a habit of accuracy which may save the student much grief in commercial work.

An aspect of precision which has hitherto not received as much emphasis in text-books on quantitative analysis as it deserves is that of theory of errors, computation rules, and retention of significant figures. An excellent presentation of the subject is given by Fales[14] and Hamilton and Simpson.[15] Students are, as a rule, ignorant of precision principles and will scarcely be impressed with their importance unless continually reminded of them in the quantitative laboratory. An interesting phase of precision arises from the fact that the atomic weights which are calculated to their absolute values, *in vacuo*, are actually applied to determination employed *in air*. Kolthoff and Furman[16] give a table of "Rational Atomic Weights," calculated to their values in air. While the error is negligible in the case of most of the heavier atoms, in some cases of the lighter elements the difference between absolute and rational atomic weights is as great as 0.1%, and in certain compounds of the lighter elements the error may be much greater.

Conclusion

The several factors above discussed, which relate to the student's part in determining precision, will necessarily vary from student to student, and it is difficult, if not impossible, to evaluate any one of them quantitatively. Any measure of the precision, as determined from actual results obtained by the student, will therefore represent a summation of all these factors. It will be of interest to illustrate such a summation in a study of precision limits for some of the typical quantitative determinations. This study will be presented in a later paper.

[14] Fales, Ref. 2, page 58, Ch. IV.

[15] Hamilton and Simpson, "Calculations of Quantitative Chemical Analysis," McGraw-Hill, 1922, Ch. I.

[16] Kolthoff and Furman, "Potentiometric Titrations," Wiley, 1926, p. 333.

HOW TO COOK A TEACHER

Select a young, strong, and pleasing personality; trim off all mannerisms of voice, dress, or deportment; pour over it a mixture of equal parts of the wisdom of Solomon, the courage of the young David, the strength of Samson, and the patience of Job; season with the salt of experience, the pepper of animation, the oil of sympathy, and a dash of humor; stew for about three years in a hot class-room, testing occasionally with the fork of criticism thrust in by a principal or a superintendent. When done to a turn garnish with a small salary and serve hot to the community.

QUALIFICATIONS OF A CHEMISTRY TEACHER*

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James A. Garfield once said that Mark Hopkins on one end of a log and a boy on the other would constitute a university. The teaching staff of this miniature university is definitely fixed. The student body, a boy in this case, may be anything in the range of ability, from the poorest to the best. With some boys it would require quite a stretch of the imagination to dignify this combination with the name "university," even though Mark Hopkins were the teacher. After all, this fine tribute to a famous teacher brings clearly to our minds the fact that the greatest single factor in any school, secondary or college, is the teacher. What are some of the qualifications of a good chemistry teacher?

To discuss the qualifications of a good chemistry teacher is to largely re-hash those qualifications common to all good chemistry teachers and these common qualifications are comparatively few. Any one good teacher has more good qualifications than are common to a group. It is, then, difficult to get together any great number of traits that are applicable to all. It is fortunate that teachers are different and I should oppose any scheme of training that would tend to make all good chemistry teachers alike. The qualities that go to make up the personalities of good teachers are among the most important of their qualifications.

I shall confine most of what I shall say to teachers of beginners, whether they are in secondary schools or in colleges. The teachers of chemistry in well-established colleges and universities who are teaching advanced work and have charge of research work are making a pretty good job of it. Advanced students can find what they want in the way of specialization if they look for it. Important as research is, I feel that much of the best effort should be put on the beginners. Get them well grounded in the fundamentals of the subject and then they can largely take care of themselves.

What is expected of chemistry teachers? The answer to this question is to be found, in part at least, in the trend of thought found in the objectives that are set up for us by the syllabus makers of the country. Some of the ideals they have set up as they pertain to the qualifications of teachers, may be summarized as follows:

Give a course satisfactory for general knowledge as well as to furnish a basis for further work in chemistry, medicine, and so forth, and meet college entrance requirements.

To be able not only to teach thoroughly the fundamentals of the subject, but to supplement these with material specially suited to the needs

* Delivered before the Division of Chemical Education of the A. C. S. at Tulsa, April 7, 1926.

of the groups of students, either in individual classes or the group in a particular community.

To present the work in such a way that pupils shall learn to observe accurately and draw sound conclusions from observations; in short, develop the scientific method.

To instill into the minds of the pupils the desire to search for truth for truth's sake, to develop habits of neatness, integrity, and resourcefulness.

To bring chemistry home to pupils by applying it to things of local interest, so pupils shall have a better understanding of their environment and the means by which it is controlled.

What qualifications must chemistry teachers have in order that these ideals may be realized? While these ideals pertain more to teachers of beginners, many of them pertain to work all along the line.

In these days of much pedagogy, as such, I am afraid that we are, to some extent at least, losing sight of the fact that the best teaching cannot be done unless teachers have a thorough knowledge of the subject. Superior knowledge does not make a good teacher by any means, and I am not sure but that mistakes are often made by getting men and women on our faculties simply because they are scholars and not because they are not only good scholars, but good teachers as well. This applies particularly to those handling beginners. Some of the poorest teaching done in our schools is done by the scholars. The point I want to make is that one cannot possibly be the best teacher without having a broad and thorough knowledge of the subject. A broad and thorough training of the teacher is absolutely essential for the best teaching.

This fundamental theoretical knowledge is absolutely necessary if the teacher is going to be able to give work that is sufficient not only for those taking one year of work, but also for those who expect to do work in medicine, more advanced work in pure chemistry, and so on. After all, it takes average persons a long time to come to the point where they fully appreciate the beauty and practical significance of the fundamental laws of chemistry. What inkling of this beauty and significance are pupils going to get from teachers who are working up to their limit? The answer is, I am quite sure, that pupils will get very little, if any, and what they do get will be in spite of their teachers.

Even with the theoretical side of chemistry, teachers should never reach the place where they are "developed." Teachers should be "developing" rather than "developed." How can teachers instill into the minds of young people the desire, let alone any ability, to investigate and solve all sorts of problems unless they themselves are intensely interested in the investigation and solution of problems? It does not make so much difference how much research they may have done, but it does make a great deal of difference as to whether they have the investigative spirit. This

is just another way of saying that teachers of chemistry should be intensely interested in the subject. The teacher of chemistry should never be a person who is interested, primarily, in some other field and is teaching chemistry simply to fill out a teaching schedule. People not interested in chemistry certainly cannot be the best teachers.

If teachers are to be able to give not only the fundamentals well, but to select and present material which is of value and interest in the particular community in which they happen to be, they should have as much knowledge as possible of subjects closely related to the theoretical work. They should be well versed in the history of chemistry, in the applications of chemistry to the industries and to everyday problems of life. Tidbits from the history of chemistry, some applications to the industries and to problems of everyday life, do much not only to add interest and value to the course, but to take the chill off of the theoretical work. I do not mean that these things should be given merely for entertainment. I do not believe in coaxing or coddling, neither do I believe in brow-beating. I am opposed to putting knowledge out in tabloid form, take it or leave it as you will, without doing something to make it a little more palatable. Good teachers of chemistry are very much interested in having pupils leave their courses with the fullest possible knowledge of the subject and a deep and abiding respect and love for their science and its possibilities. Too many teachers are taking the easier route and are offering courses rather than teaching them.

What are chemistry teachers doing to train pupils to observe accurately and to draw sound conclusions from their observations, or what qualifications must teachers have to instill the scientific method into the minds of young people? Here is where the real pedagogy comes in. Certainly one of the prime qualifications of good chemistry teachers is that they must be willing to work at their jobs. As I have said before, a broad knowledge of subject-matter will not, necessarily, make those who possess it good teachers. A good teacher must be interested in building up the department, getting the best supplies the institution can afford, trying out different methods and constantly checking results, and eliminating the weak places.

It would be a good thing if all teachers of chemistry could have a little work in pedagogy, say at least some work in psychology and methods. It is rather unfortunate that young teachers cannot get more training in the teaching of chemistry under the direction of trained teachers of chemistry. Of course it should always be remembered that you cannot learn to teach well until you have something to teach. Then, as I see it, another qualification of a chemistry teacher is that he or she should do some work in pedagogy as such, especially some work in practice teaching under skilled supervision, but above all this there must be a desire to continually improve the work. I believe that a major in chemistry and a minor in educa-

tion is a better combination for a chemistry teacher than a major in education and a minor in chemistry, although this is pretty much reversed in some places.

If pupils are going to learn the all-valuable scientific method, the teacher should know enough of pedagogy to know that pupils will not get it by simply lecturing to them. The pupils, themselves, must take an active part in the thinking and in the discussions. For several years we have been teaching what we are wont to call science and when I look out into the world to things as they are, I am not quite so enthusiastic as I should be when I note that practically all vestige of scientific method has been removed from the solution of problems of our social and domestic life, and to some extent, from scientific problems themselves. It is largely as if teachers have failed in making effective their science and the scientific method. Our chemistry teachers must be people who can make the subject real, not only to those who are going to specialize, but to the great numbers that take it merely for its informational value, and often for just five or more hours of credit in a physical science.

Good teachers of chemistry are patient and sympathetic. So often when pupils are wrestling with their difficulties they get an unsympathetic, if not a deaf ear, to their pleas for help. It takes a great deal of patience and effort on the part of a teacher to get down on the level with the pupil, yet this is very important. From the standpoint of the pupil, a great many teachers do not actually help, but try to impress on the pupil the marked contrast presented by the vastness of their own knowledge compared with the very limited knowledge of the student. I am quite sure that a great many more could be rescued from failure if some teachers in the profession were more sympathetic. We should make it almost impossible for a boy or girl to fail, if they have average ability and work hard.

If teachers are to instill into the minds of young people the desire to discover truth for truth's sake, develop habits of neatness, resourcefulness, honesty, and the rest, they should be people of high ideals and high moral character. They should be teachers to whom pupils could and would go for counsel and advice. For beginning students one teacher of this sort is worth a dozen scholars. In general, scientists have been and are prone to serve the best interests of humanity and that is as it should be. Would it not be well if our teachers of chemistry would put themselves into places where they might do more of the leading? In these days when people are using scientific terms to explain things in such a way that they show clearly that they do not know the full significance of these terms, would it not be well for the thoroughly trained scientist to do at least a little to put the public straight on some of these things? Teachers should not only be interested in their departments and the institutions in which they work, but they should manifest some interest in the communities in which they line.

Even those who oppose science these days do not question the great advances in science, the pursuit of it, or the practical side of scientific training. What they do question, more than anything else, are the esthetic and moral sides of scientific training. It is probably not the business of chemistry teachers to be preachers of morals, but they should be persons of such character and present their work in such a way as to stimulate the imagination, broaden the sympathies, and clarify the mind, and thus lead pupils to live on higher and better planes.

In summing up the qualifications of a chemistry teacher we may say with Sir Michael Foster that "In the first place, above all things, his nature must be one which vibrates in unison with that of which he is in search: the seeker after truth must himself be truthful, truthful with the truthfulness of Nature. For the truthfulness of Nature is not wholly the same as that which man sometimes calls truthfulness. It is far more imperious, far more exacting. Man, unscientific man, is often content with 'the nearly,' and 'the almost,' Nature never is... In the second place, he must be alert of mind. Nature is ever making signs to us, she is ever whispering to us the beginnings of her secrets: the scientific man must be ever on the watch, ready at once to lay hold of Nature's hint, however small, to listen to her whisper, however low. In the third place, scientific inquiry, though it be pre-eminently an intellectual effort, has need of the moral quality of courage—not so much the courage which helps a man to face a sudden difficulty as the courage of a steadfast endurance."

Psychologists Measure Persistence by Puzzle. If scientists keep on at the present rate it may be possible for whole personalities to be charted out on paper for all the world to read.

The useful trait of persistency is now being measured in percentage and decimal points by enterprising experimental psychologists. Dr. John J. B. Morgan of Northwestern University and Hazel L. Hull of the State University of Iowa have devised a 'persistence stimulus" in the shape of an alley maze with more and more difficult problems to try out on victims, ending in an impossible one, according to a report about to be published.

It was found by exercises on this scientific puzzle that a person could be rated in a scale of relative persistency by a stranger as accurately as he could be placed in the same scale by an intimate personal acquaintance basing the analysis on repeated observations.

"Our progress," the authors declare, "in the measurement of many mental factors has been retarded by an over-emphasis on records of quantity and quality of work produced per unit of time. Persistence seems to be a trait that cannot be measured in the traditional manner. For this reason emphasis was placed on the creation of a situation that would produce an expression of the trait, even though we had to use a qualitative measure of performance."—*Science Service*

THE APPLICATION OF COLLOIDAL CHEMISTRY TO FOODS

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The chemistry of foods presents many colloidal phenomena. A colloidal condition is one in which the particles of a solid are too large to be in solution and too small to be in suspension. The particles in a starch paste are not large enough to be held in true suspension nor are they small enough to go into a solution, but when cooked they form a semi-soluble paste. Such substances which form colloidal suspensions in liquids are known as colloids. Gelatin in water, egg albumin in water, cream in milk, oil in soapy water, starch paste, and egg in vegetable oil such as mayonnaise dressing are all examples of colloidal suspensions. Our foods come from plants and animals which consist mostly of colloids. Pure cellulose is said to be a typical gel and shows typical swelling phenomena and on solution yields the highly viscid liquids which are characteristic of the hydrated emulsions.

Emulsions and our ability to stabilize them form a large part of our interest in the colloidal field. An emulsion is made by combining two nonmiscible liquids in such a way that one is suspended in the other. The two liquids are ordinarily spoken of as water and oil; the suspended liquid is known as the internal phase and the suspending medium as the external phase. When the phases exchange place the emulsion is said to have been reversed. The following are emulsions, mostly of the reversible type: cream, milk, mayonnaise, egg yolk (oil in a hydrated protein) and egg albumin. According to Fischer and Hooker, an emulsion is stabilized only through the addition of a lyophilic colloid, such as the protein in the mayonnaise. The amount of the colloid must be sufficient to bind all the water or vinegar if an emulsion showing real permanence is to be produced. Recent directions for the making of mayonnaise stress the addition of the acid to the egg before any of the oil is added, while others add the oil and vinegar alternately little by little. Bancroft says that experts can add the ingredients in any order, all at once or in separate portions, hot or cold and mayonnaise always comes. The proportion of egg to that of oil has been suggested as the determining factor, although the amount of oil varies with the different vegetable oils. Robinson says that age of the egg affects the quality of the emulsion formed. This is probably due to the decomposition of some of the proteins. He further says that the separation is that of either the water or the oil; and that the water will not separate out if the content is kept between 12–15%, while freezing, warm weather, and agitation will cause the oil to separate out. Recent experiments show that $^3/_4$T of a starch paste or $^1/_4$T gelatin solution may be used in making mayonnaise instead of 1 egg yolk. The latter must be kept cold to maintain an emulsion.

Early writers and chemists speak of casein as an unstable protein which is readily precipitated by acid or rennin; and of lactalbumin as a protector of casein against coagulation. Cow's milk contains 3.02% casein, 0.53% lactalbumin and is readily coagulated. (Human milk is 1.03% casein and 1.26% lactalbumin and is not readily coagulated.) Casein precipitated from cow's milk produces relatively coarse lumps which are bad for infants. By adding gelatin, another protective colloid, the growth of the curdy precipitate can be prevented; or if added in smaller amounts, the curd forms in soft fine particles. Jacobi advocated the addition of gelatin to cow's milk for infant's diet as it delays coagulation. A recent article by Palmer which disproves the protective characteristic of lactalbumin, tends to explain the stability by the effect of the salts. He says that milk coagulation is the destruction of the physical state of its chief colloids, calcium caseinate, lactalbumin, and calcium phosphate.

A film or scum forming over boiled milk or cocoa is not due to the instability of the colloidal solution, but to an action of the salts causing some of the proteins to become dehydrated to the point of coagulation. Beating cocoa vigorously for a few minutes breaks the scum and redistributes the precipitants. According to Palmer, heating precipitates the phosphate and calcium caseinate, both of which are necessary for a normal reaction of milk toward rennin. The rennin clot is probably formed by the enzymic action on the casein in the presence of calcium. The formation of this clot is a reversible action as water or whey separates from the gel mass upon standing.

The creaming quality (Palmer) of milk is correlated with the viscosity and content of colloids, the higher the protein content the better the creaming quality. Bancroft says that cream rises more completely in a deep vessel than in a shallow pan as the finer particles of butter fat are caught by the coarser ones and are swept upwards due to the concentration of the coarse particles per unit of cross section. This, of course, is increased by low temperature. Experiments show that the addition of gelatin leads to a quicker and more exhaustive creaming. This may be explained by the fact that heavier proteins go to the bottom and the light fats rise to the surface.

The whipping of cream presents many a housewife with untold difficulties. If the aging of cream improves the whipping quality, possibly the acid formation acting on the colloids increases their stability. Thin cream is generally lacking in sufficient colloids and will not form the emulsion unless prepared colloids are added. The use of egg whites, powdered sugar, powdered milk, salt, caramel, gelatin, junket, and cornstarch, each facilitate the whipping of cream to a small degree, and each to practically the same extent. None of these prove as effective as a low temperature and the development of lactic acid. Whipped cream is sometimes termed a

"double emulsion," since cream is an emulsion of oil-in-water which must be maintained while air is incorporated into the water to form a new emulsion. Thus, it is quite necessary that the colloids be of superior quality, that is, that they be able to hold water in order to hold up under this double action.

It is not uncommon to manufacture artificial milk from butter fat emulsified with water and skim milk powder. Shipping sweet milk is rather expensive as one cannot be too certain of the keeping quality and at the same time must pay express charges on the large amount of water contained in fresh milk.

Cream is an emulsion of oil-in-water, since the fat globule is encased in a protein membrane and floats about in the milk. In churning, the protein membrane surrounding the fat globule splits off and we have an emulsion of water-in-oil, or butter. Artificial butter and margarines are largely animal fats and plant oils manufactured in such a way as to make them colloids or emulsions of the water-in-oil type.

Gelatin is much used as a food in the form of gels. A gelatin jelly is spoken of as a viscous medium in which water is dispersed and in which the tendency to jell is so strong that no special precautions are necessary. The setting of gelatin is influenced by the hydrogen-ion concentration, it being less in the presence of acid and more in an alkaline solution. The addition of such acid as lemon juice appears to have a two-fold object; for the flavor and to increase the water absorption and swelling of the gel, since a slightly acid solution causes colloids to take up more water.

Experiments show that boiling a gelatin solution for as long as twenty minutes does not destroy the power of gelation. Kept at body temperature, gelatin solutions lose their power of gelatinizing in one or two days as the proteins probably deteriorate. For that reason it is advisable to put the solution in a cool place to set to a gel. One of the properties of colloidal jellies is that they set in solid form readily at low temperature. Raw pineapple added to gelatin destroys the power of gelation because there is an enzyme in the pineapple which acts on the protein in the gelatin. If the pineapple is cooked the enzyme is destroyed and the gelatin will set.

Gelatin is the most widely used protective colloid in food preparation. Glucose, corn syrup, albumin, glycerine, and gum arabic are also used for the same purpose in various foods. Many or all are sometimes used in such candies as gum drops, marshmallows, and divinity not only to prevent crystallization, but to keep them in salable form.

As an emulsifying agent (in milk), gelatin keeps the fat in a finely divided condition. When casein is precipitated, by souring or otherwise, it carries down with it a considerable portion of fat, and troubles that have been experienced by the appearance of undigested fat from the milk in the stomach, have been relieved by the addition of gelatin to the milk.

Some regard gelatin in ice cream as a filler. It would be rather an expensive filler if that were its only use in the cream. The addition of gelatin or egg helps to prevent the formation of crystals and the coagulation of the casein of the milk, and gives the smooth, velvety texture desired. Recent reports show, however, that the addition of protective colloids does not insure against crystallization if the content of lactose in the milk is not kept below the saturation point.

Why do we add salt or vinegar to the water when poaching eggs? Just because our great grandmothers did? And why does egg albumin harden or "coagulate" when heated above 73°C.? It is changed from a substance that appears to be soluble in water to one insoluble. Chick and Martin believe that there is a reaction between the protein and water which leads to precipitation of the former. They believe the change to be influenced by the concentration of the H ions and that these H ions disappear as heat is applied. Acid lowers the coagulation temperature and acid is removed as the rate of coagulation falls. According to a recent article by Philip Frank, one might infer that lowering of the coagulation temperature would be desirable from the standpoint of digestibility, as he states that the total digestion is most rapid in the albumin not heated beyond 75°. Pauli says that no doubt the salt increased the catalytic power of the H ions normally contained in the albumin solution, the presence of which is due to the electrolytic dissociation of the protein molecules; then the salt induced there by an extraordinarily strong increase of the denaturation (slight hydrolysis of protein) rate.

If your cook puts too much salt in the soup, the salt content may be greatly reduced by the addition of an egg as the protein probably absorbs a large amount of the salt. Egg is often added to soup stock for the purpose of clarification. Here the protein precipitates all loose particles so that they may be easily skimmed off. Egg is used in clarifying coffee, but at the same time performs a benefit to humanity by precipitating the tannic acid as the egg coagulates. Tea and coffee themselves are colloidal solutions.

Other examples of colloidal phenomena which might be discussed at length, will only be mentioned here. One author states that in the manufacture of phosphate baking powder, the calcium phosphate is protected from the moisture by an admixture of starch and it is well known in the trade that calcium phosphate must not be too fine nor the starch too coarse, as the latter coats the calcium phosphate and acts as a protecting film and prevents absorption of water. Starch is manufactured and sugar refined by colloidal-chemical processes. Gelatin may be used as a protector in pickle baths.

Bancroft says that a colloid which is stabilized by a strongly adsorbed non-electrolyte such as sugar will behave very much like a water-soluble

colloid. If we mix colloidal solutions of two substances, each of which adsorbs the other, the mutual adsorption will have the same effect on the adsorption of the peptizing agent. If it causes a decrease in adsorption of the peptizing agent, this means a decreasing stability of the colloidal solutions and may lead to precipitation. This would be true of sugar and gelatin and probably accounts for the precipitation of casein in custards when too much sugar is added. If custard cooks too long and consequently curdles, pour it at once into a cold bowl and beat vigorously with a Dover egg beater. This will often bring back the custard to its original smoothness.

In making fruit jellies, certain percentages of pectin, sugar, and acid are necessary for an acceptable jelly to form. This bears out the point that the addition of acid to the gelatin solution increases the swelling of the gel. Pectin, being a kind of starch, is the colloidal substance. One writer says that the greater the acidity (within certain limits) the lower the amount of sugar necessary. Recent experiments with fruit jellies show that upon reducing the percentages of pectin, sugar, and acid to the point where a jelly will not form, and then adding 0.5–1.0% calcium chloride, jelly formation occurred. Two possible explanations were offered: (1) Calcium forms with pectin a higher gelatinizing power. (2) Calcium chloride increases the H-ion content by lowering the buffering action for the pectin. The most efficient acid for jelly making is thought to be tartaric, since it furnishes a higher concentration of H ions than either malic or citric.

A vinegar sauce thickened with starch is sometimes used with vegetables. It has been the experience of some that the sauce of good consistency soon becomes watery due to the hydrolyzing effect of the acid on the starch, causing it to lose the power of gelation. The same process may take place in cream of tomato soup which stands for some time after the acid has been added to the cream sauce. This change is not so marked since most of the acid has been neutralized by the soda.

The mixing of flour and liquid in making dough as well as the swelling of the dough and the changes taking place in baking present interesting phases of colloidal actions. The fermentation is a process which can only occur in substances which absorb water for the use of the yeast and permit swelling to get rid of the carbonic acid. The gluten absorbs the water and forms the elastic mass or gel which stretches under the influence of the carbon dioxide. There is some discussion as to whether the strength of the flour depends upon the tenacious gel formed by the gluten or upon the salt or acidity content of the flour. A recent article by Gortner indicates that the strength of the flour probably depends to a great extent on the physical properties of the gluten as it is laid down in the wheat berry. Flours vary greatly in the gluten quality but are quite uniform in gliadin. He also states that the weak flours are suited to the manufacture of pastry

and crackers rather than for leavened bread. Colloidal phenomena stand out in the baking process as the proteins are coagulated by the heat and produce the firm, porous structure.

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Civilization depends not only upon the knowledge of the people, but upon the use they make of it. If knowledge be wrongfully used, civilization commits suicide.—CALVIN COOLIDGE

ELEMENTARY CHEMISTRY OF THE LONG AGO

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MESSRS. DAYTON AND NEWMAN:

After a careful examination of your "Metrical Stories in Chimistry and Natural Philosophy," I do not hesitate to give it my unqualified approbation. It is a fact which all must acknowledge, that our youth are lamentably deficient in chimical knowledge. Frequently we see boys and even girls studying Botany and Astronomy, to the entire neglect of Chimistry. Now this should not be. A knowledge of Chimistry is far more important for children that expect to have any concern with domestic affairs, than Botany, Astronomy or Mineralogy. The pleasing style, the simplicity of the language, the important truths contained in your Book, and its cheapness, are recommendations sufficient to place it in the hands of every youth.....

New York, May 25, 1842. P. B. HEROY

Such was a recommendation of the little volume of "Metrical Stories in Chimistry and Natural Philosophy," designed for youth by a teacher and printed eighty-four years ago. It contains 144 pages of doggerel of various grades of quality, and it is thought that some specimens might be of interest to the readers of the JOURNAL, showing how chemistry was once taught in secondary schools.

It is obviously impossible to give the titles of all the verses, but a few examples will give an idea of the general scheme of instruction.

First we have a rhyme about "Chimistry;" then "Matter;" "Attraction;" "Affinity;" several verses about "Light;" a number about "Caloric," including the stories of "Jonny Scott and His Eggs;" "Sarah and Her Gloves;" and "Goodness of God Manifested in Covering the Earth with Snow;" "Water;" "Evaporation;" "Story of Little Marion Culling Flowers;" "Master Warren Sprinkling the School-Room;" "Little Mary Who Was Sick of a Fever;" the sad "Story of Peter and His Powder;" then a number of verses about electricity, gases, and various simple inorganic substances. Many of the tales contain the inevitable moral which used to be considered necessary in any story for youth. Questions are also asked at the end of each poem dealing with the subject-matter. In this respect the book resembles modern texts.

Underneath a wood-cut representing "Henry's Teacher Telling Him about Chimistry" is the following rhyme:

The glorious truths of Chimistry,
If they are read aright,
Will ever wake in you and me
Sweet sources of delight.
It tells of what the rocks are made,
The earth, the sea, the air;

The jewels in earth's surface laid,
And all the treasures there;—
How floods are form'd, and clouds collect,
And winds and tempests blow,
And how the tints are form'd that deck
The earth's gay surface so;—
How in the air the meteors start,
And muttering thunders roll,
And how the forked lightnings dart,
And flash from pole to pole.
And O! how many a lovely sight
The eye is made to see,
That reads the merry tales aright,
Of charming Chimistry.

Imagine giving the following to a freshman:

The following is the history
Of Chimical Affinity,
Of what he loves and where he lurks,
And all the rules by which he works.
The first is this—he always binds
Together things of different kinds.
The next—he always firmly pulls
A body's smallest particles.
The third is—when he's tied a lot,
No human strength can break the knot.
The fourth is—when he can not bind
Together things of different kind,
He takes a third who straightway goes,
And makes them then unite and close.
The fifth is this—with different might
He makes the things he joins unite.
The last is this—when bodies run
By his command and make but one,
The temperature will alter so,
'Twill heat like fire or freeze like snow.

How simple was the old theory of indicators.

Within a glass of water put
A fair blue violet,
Blue cabbage leaves, or radish root,
A clear, bright blue you get.

Then pour Sulphuric Acid in,
And all the blue is fled,
You'll see the change will quick begin,
Till all is turned to red.

The acid is like water—white—
Why did it change the hue,
And make the red appear so bright,
Which was so fair a blue?

Because they mix another way,
When we the acid pour,
And they reflect a different ray
From what they did before.

Thermochemistry likewise presented few difficulties:

Caloric

Caloric is a subtil fluid which exists in every thing. It causes the sensation of heat, just as sugar causes a peculiar sensation, called sweetness. It cannot be seen, and is known to exist only from its effects.

Caloric—The Cause of Heat and Cold

Caloric is the element of heat. It goes from a hot body to a colder, till they are both of the same temperature. Its natural tendency is to make all things equally hot or cold.

Included in the verses on the expansive power of caloric are these

Glass stoppers oft so firmly stick
In the decanter's stem,
You scarce can get them from the neck,
Except by breaking them.

But plunge them in warm water well,
Or wet the glass about
The griping mouth expands pell-mell
And lets the stoppers out.

And what some students never seem to learn is:

The thinest thing will soonest bear
T'expand or to contract,
The thickest glass and earthenware
Is always soonest crack'd.

Domestic economy was also taught:

Molasses and wine
Expand much the more
When Summer suns shine,
Than when Winter winds roar.
When Summer time passes,
And Winter comes round,
Buy oil and molasses—
They'll cheaper be found.

It is necessary to skip a number of amusing rhymes and learn about nitric acid:

Nitric Acid

The Nitric Acid
You'd think was placid,
With neither color nor smell;
But put in a rose,
Or whatever grows,
'Twill burn up and wither it well.

A drop on the skin
Will prick like a pin,
Or burn like a coal from the fire,
For the Oxygen pops
From the acid in drops,
Consuming the skin in its ire.

The reason we learn,
Of the sting and the burn,—
The Oxygen leaves it so free,
That it flies on its wing,
And alights on a thing,
And burns and corrodes it, you see.

Beneath a wood-cut showing "Helen's mother telling her of what water is composed, and how the little fishes live in it," is the following:

Said Oxygen to Hydrogen,
"Let's meet—I think we ought to,"—
They scarcely had united, when
They strangely turned to water.

Though Hydrogen is twice as big,
When joining with the other,
Yet Oxygen don't care a fig—
Outweighing eight times over.

The little fishes in the flood,
That sport around so gayly,
Suck Oxygen to make their blood—
And they must have it daily.

When iron gets wet, as oft it must,
The Oxygen will meet it,
And cover it with a coat of rust,
Because it likes to eat it.

And since the two have joined their hands,
Their choicest gifts to scatter,
The earth with all her seas and lands
Has been supplied with water.

At the risk of making this "book review" too long, the properties of sulfuric acid may be included:

When Sulphur takes its greatest share
Of Oxygen within it,
Sulphuric acid starts up there,
Perfected in a minute.

Of all the acids on the globe
This is the greatest glutton,
The slightest drop will eat a robe,
And gnaw a metal button.

'Twill bite an iron bar in two,
As people do a radish,
And one small drop on me and you,
Would make us rather sadish.

If on your skin you get a drop,
You should not pour on water,
It will not make the burning stop,
But make it rage the hotter.

But put some potash on the spot,
Or chalk or even ashes,
'Twill gradual die till not a jot
Is left to send its flashes.

If I should ever swallow it,
(I'd not for mines or specie),
The safest remedy I'd get,
Is chalk or else magnesia.

RELATIONS OF MATHEMATICS TO CHEMISTRY

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Mathematics is the only language by which relations may be exactly expressed: hence it is the most satisfactory method of expressing scientific facts. Mathematics is the only universal language understood by all civilized races. Thus it is an indispensable instrument in the hands of scientists of today.

To illustrate the wide use of mathematics by chemists, I have examined typical publications of the four leading scientific nations of the world and tabulated the number and calculated the percentage of articles which contained graphical representations and algebraic or differential equations. An article containing graphs was counted whether or not it contained either algebra or differential equations. The algebra was counted only in those articles in which it appeared unaccompanied by differential equations.

TABLE SHOWING THE NUMBER OF ARTICLES AND THE PERCENTAGE CONTAINING MATHEMATICAL EQUATIONS

	Year	Total number of articles	Graphs		Algebra		Differential equations	
			Number	Per cent	Number	Per cent	Number	Per cent
Journal of the American Chemical Society	1921	324	80	24.69	15	4.63	43	12.97
	1922	259	90	25.07	14	3.90	42	11.69
	1923	414	101	24.17	7	1.69	50	12.08
	1924	370	95	25.64	10	2.70	31	8.57
	1925	435	125	28.74	38	8.74	33	7.59
	Total	1902	491	25.86	84	4.33	199	10.58
Industrial and Engineering Chemistry	1921	354	80	14.97	13	2.43	13	2.43
	1922	525	62	11.81	13	2.48	14	2.66
	1923	577	112	19.41	7	1.21	27	4.68
	1924	482	142	29.45	12	2.49	31	6.43
	1925	611	129	21.12	16	2.69	23	3.76
	Total	2549	525	19.35	61	2.65	108	3.99
Journal of the Chemical Society	1921	243	41	16.88	11	4.53	15	6.17
	1922	347	80	23.05	14	4.04	30	8.652
	1923	300	83	27.68	16	5.33	33	1.10
	1924	363	85	14.78	15	4.09	32	8.81
	1925	440	87	19.77	13	2.95	30	6.81
	Total	1693	376	20.43	69	4.19	140	8.89
Bulletin de la Société Chimique de France	1925	151	32	21.18	19	12.58	19	12.58
Berichte der Deutschen Chemischen Gesellschaft	1921	368	23	6.25	13	3.53	3	0.81
	1922	438	21	4.79	13	2.97	3	0.68
	1923	443	19	4.34	12	2.74	8	1.45
	1924	413	27	6.54	7	1.72	5	1.21
	1925	481	47	9.75	13	2.70	7	1.45
	Total	2143	147	6.34	58	2.71	26	1.23

The publications thus tabulated covered a period of five years, from 1921 to 1925, inclusive. They were: *The Journal of the American Chemical Society* and *Industrial and Engineering Chemistry* for the United States, *The Journal of the Chemical Society* for England, *Bulletin de la*

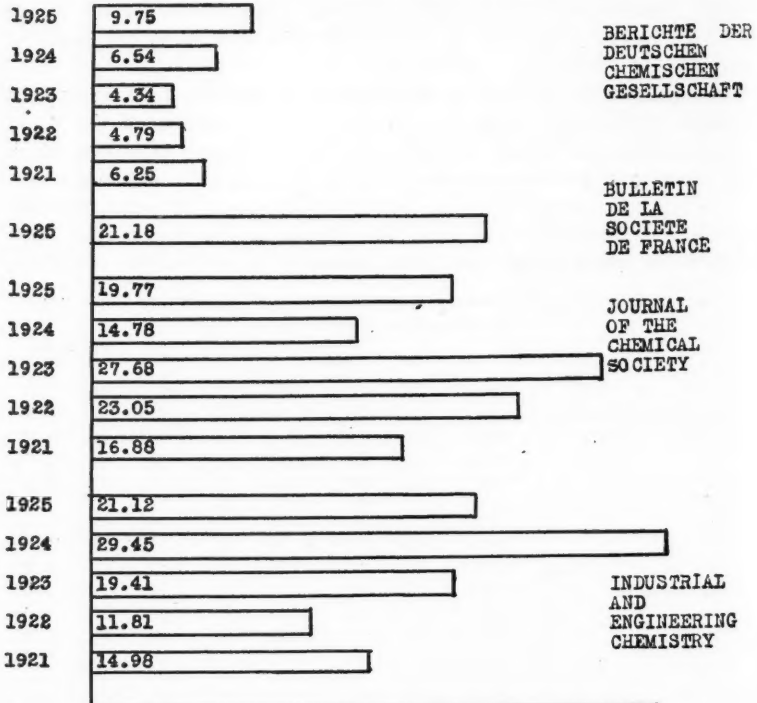

FIG. 1.—Graph showing percentages of articles in various periodicals containing graphical representations.

Société Chimique de France for France, and *Berichte der Deutschen Chemischen Gesellschaft* for Germany. The material thus examined will be found both in tabular and graphical form. The fact that the percentages found in the *Berichte der Deutschen Chemischen Gesellschaft* are so much below

those found in any other of the publications is probably due to the fact that all work on physical chemistry is published separately.

Though the variation in percentages from year to year is great, the figures seem to indicate that for the intelligent reading of these periodicals

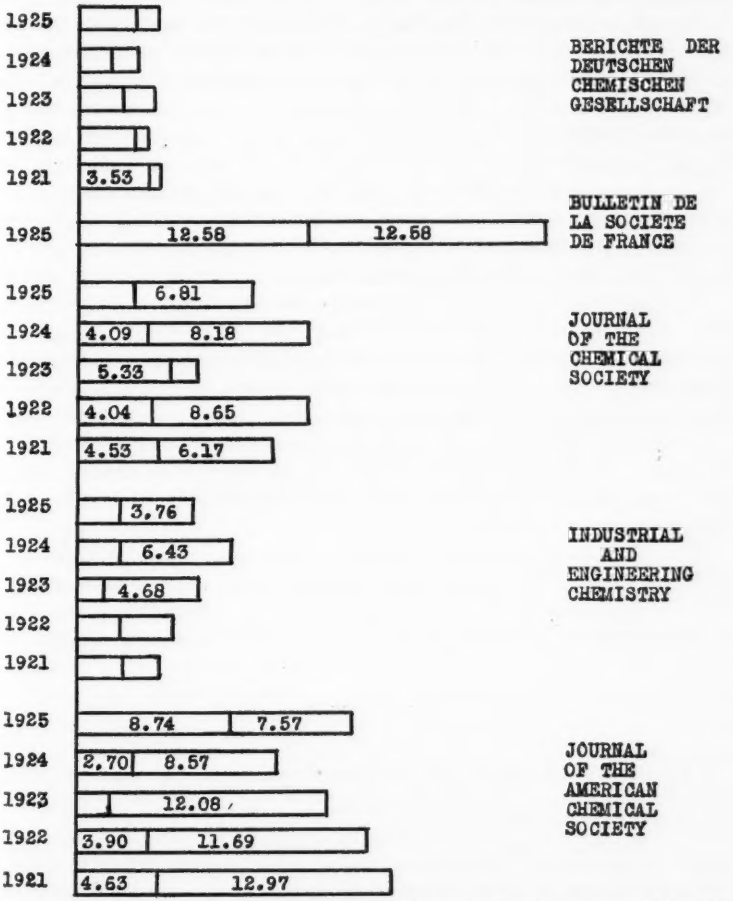

FIG. 2.—Graph showing percentages of articles in various periodicals containing (1) algebraic and (2) differential equations.

an elementary knowledge of algebra and calculus is very desirable if not necessary.

The greatest universities of our country have recognized the need of mathematical training for chemists, and require that students who are

studying in the department of chemistry, or chemical engineering, shall have courses in algebra, analytical geometry, and calculus. Many of the leading colleges are adopting courses in unified mathematics which treat those subjects in an elementary way, and at the same time show their relations to practical problems.

Though an elementary knowledge of mathematics may suffice for the intelligent reading of most of the articles included in these publications, this is altogether inadequate for those who are engaged in the research work which produces them. The men who meet the mathematical problems presented by physical and chemical phenomena need adequate mathematical training. In some cases even this training is not sufficient, and the problems remain unsolved until some genius attacks them. The method generally employed in universities for the solution of difficult mathematical problems seems to be that of referring them to the mathematics department. Several instances of this were evident in the journals.

It might be well to consider the needs of the beginning student in chemistry. It seems to me that his needs could easily be met by an elementary knowledge of algebra. In general the formulas given in beginning textbooks require only sufficient knowledge of algebra to enable the student to substitute numbers for letters in equations.

However useful mathematics may be to the chemist, it is not absolutely necessary. Many non-mathematical chemists have done brilliant work, and, as the tables show, many of the articles in the periodicals contain no mathematics.

Knowledge of mathematics enables a man to correlate and interpret his own results. The function of mathematics is to express clearly and concisely what cannot be expressed in any other way. A mathematical statement is already correlated and digested. It needs only to be applied.

Element Found by Mme. Curie May Help Cure Syphilis. Salvarsan may have a rival in polonium, the radio-active element isolated by Madame Curie, which is now being tried out in treatment of syphilis.

This very active element closely resembles bismuth which is a recent and important addition to the list of drugs that have a specific action against syphilis. Its valuable properties suggested to Dr. C. Levaditi of the Pasteur Institute the possibility of trying the effects of the allied element on animals inoculated with this disease.

X-ray examination of the rabbits used by Dr. Levaditi and his students showed large quantities of polonium concentrated around the syphilitic lesions though the organism that caused the disease was not killed by the injection of the drug into the blood stream. This may indicate that the injected polonium was being marshaled into service along with the white soldier cells of the blood and helps hold the disease in check.—*Science Service*

TEACHING QUALITATIVE ANALYSIS*

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Let us assume that we are dealing with the privately endowed institution not giving graduate work. The chemistry department in this college or university will probably give a course to those students who desire a cultural knowledge of chemistry, thus doing its part in popularizing chemistry. It may also give special courses designed to fit the particular needs of the students in this school. It will undoubtedly be doing its part in the preparation of students for engineering, dentistry, home economics, medicine, and other professional subjects which these students will continue at the end of two, three, or four years, in professional schools.

General chemistry (preferably including or followed by a course in qualitative analysis) will satisfy the needs of several types of engineers. The best medical schools now prefer a bachelor's degree for entrance and the entrance requirements in most medical schools are being increased. The medical schools are coming to a fuller realization of the importance of chemistry to medicine and often prefer that the student major in chemistry during his pre-medical work. General chemistry, qualitative analysis, quantitative analysis, and organic chemistry are required by most medical schools. In addition to this, physical chemistry is preferred by several. Organic chemistry is also required for most home economics majors.

This chemistry department will also be preparing students to be chemists. It will try to so prepare these students that they may be able to pursue their graduate work in chemistry in any of the best graduate schools.

A review of 70 college and university catalogs indicates that the following courses are considered as fundamental for a chemistry major: general chemistry, qualitative analysis, quantitative analysis, organic and physical chemistry.

In our model school it would be almost impossible for a chemistry major to take more than one course in chemistry during any given semester and still satisfy the requirements in English, French, German, mathematics, physics, history, and the social sciences. We will agree that general chemistry requires one year, and most schools give one year of physical chemistry. Qualitative analysis may be included in the general chemistry course, giving from two to four more hours of work in the course than would otherwise be given. This plan would leave one year for each of the other fundamental subjects. On the other hand, qualitative analysis might be given during the second year, dividing up the third year for quantitative analysis and organic chemistry, each course being given one semester. It would also be possible to give qualitative analysis during the first

* Delivered before the Division of Chemical Education of the A. C. S. at Tulsa, April 7, 1926.

semester of the second year and quantitative or organic chemistry during the second semester, leaving the third year for either quantitative analysis or organic chemistry.

We find all of the plans being tried and different conditions will probably warrant different plans. Some teachers feel that organic chemistry can be given in half a year and others feel that this is sufficient time for quantitative analysis. In order to see what the modern tendency is in dealing with qualitative analysis we have studied the recent catalogs of a considerable number of schools.

President Hughes, of Miami University, made a report to the Association of American Colleges showing the result of a wide-spread inquiry concerning the standing of graduate work done at various colleges and universities in the country. This is, perhaps, the most reliable selection that can be obtained at the present time. A study of 10 out of the 17 schools leading in chemistry shows that four schools give special courses in qualitative analysis during the second year, and six give qualitative analysis during the first year as a part of the general chemistry course. They all give physical chemistry.

A study of 21 out of 40 schools granting doctorates in chemistry during the last five years [cf. THIS JOURNAL, **3**, 78 (1926)] shows 13 schools giving special courses in qualitative analysis during the second year and 8 giving it as a part of the general chemistry course. All of these schools give physical chemistry.

The Association of American Universities is now taken as our standardizing agency again. Nineteen out of 33 universities and colleges having a complex organization and usually having graduate schools attached were studied. Eleven of these schools give special courses in qualitative analysis during the second year and 8 give it as part of the general chemistry course. All of these schools give physical chemistry.

A study of 45 out of 121 colleges and universities approved by the Association of American Universities, not included in the above list, shows that 32 give special courses in qualitative analysis during the second year. Of these 32 schools 21 give physical chemistry and 11 do not. Thirteen schools give qualitative analysis during the first year in connection with general chemistry. Of these schools 10 give physical chemistry and 3 do not.

Our study thus reveals a tendency on the part of the larger schools and universities to include qualitative analysis in general chemistry. This tendency would probably be more pronounced if it were not for the fact that students in such institutions often double up on their chemistry courses, this being possible through carrying heavier loads or leaving out courses and activities required in the smaller schools.

The smaller schools show a decided tendency to give qualitative analysis

during the second year. A number of these schools do this at the expense of physical chemistry. It may be said in favor of this plan that a great deal of physical chemistry can be taught with a more advanced course in qualitative analysis. It is a common thing among the rest of the schools giving a special course in qualitative analysis during the second year to call this year analytical chemistry and to devote the first semester to qualitative analysis and the second semester to quantitative analysis. In many such cases these schools then allow the students to take an advanced course in quantitative analysis along with organic or physical chemistry during the last two years. This would be done at the expense of a course in biology, physics, drawing, or some other course essential to a thorough foundation in scientific work and would, therefore, be undesirable.

There are advantages in both plans. It may be that qualitative analysis, when given as a part of general chemistry, is better adapted to the larger schools and that special courses in qualitative analysis are better adapted to the smaller schools, but on first thought the opposite would seem to be true. Perhaps the question is decided according to the comprehensiveness of the course which we propose to offer in general chemistry. It is true that in many cases one semester of quantitative analysis satisfies the requirements for pre-professional courses and thus allows opportunity for a more advanced course in qualitative analysis than could be given in connection with general chemistry. On the other hand many teachers do not consider that one semester is enough time for a thorough training in the fundamentals of quantitative analysis. In the same way organic chemistry is given in one semester or one year according to the amount of ground which is to be covered. A home economics student may not need much work in aromatic organic chemistry, while the chemistry major will. In the smaller schools it is probably best to design a good four-year schedule for the chemistry majors, and then give special courses or lower the requirements for students not desiring such thorough courses.

In our university we have worked on this basis, making all of our fundamental courses five-hour courses each semester. This provides for three lecture, quiz, or recitation periods, and two three-hour laboratory periods a week in each subject, except in the case of quantitative analysis, where one lecture period is replaced by an extra three-hour laboratory period. This gives us one year each for general chemistry, quantitative analysis, organic chemistry, and physical chemistry. This means that qualitative analysis is given during the first year in connection with general chemistry.

Having chosen the year in which we will teach qualitative analysis as the first year, and knowing that our choice is in accord with the practice of a number of the best schools, we now wonder when we should begin this course. The universities which are using our chosen plan, and which operate on the four-quarter plan, usually give qualitative analysis during

the third or last quarter. Most of the other schools start qualitative analysis at the beginning of the second semester of general chemistry.

Since our school is operated on the semester basis, we tried the latter plan. It has the advantage that the laboratory work in qualitative analysis is not started until the students have studied valence, balancing equations, and a few typical metals. In this case, of course, the laboratory work in the first semester would consist of general experiments similar to those found in the laboratory manuals designed to accompany most college texts in general chemistry. We tried this plan and found that it could be carried out, but that it was very undesirable, because many of the experiments necessarily dealt with material not studied in the text until late in the second semester.

We, therefore, decided to start qualitative analysis at the end of eight weeks and spread the general experiments throughout the year's work, so that they might be taken up just before or after related subjects are studied in the text. The only real difficulty seemed to be that the students would not be sufficiently advanced in their text-book work to work intelligently on qualitative analysis in the laboratory. We met this difficulty by using one of the laboratory periods each week for the first eight weeks for study and drill periods. During two or three weeks we used both periods. This enabled us to cover sufficient ground by the end of eight weeks for the students to accomplish something in qualitative analysis. Some of the earlier studies in general chemistry, such as valence, nomenclature, formulas, reaction writing, etc., require a great deal of drill and we found that these long laboratory periods afforded a wonderful opportunity for this sort of thing. The other laboratory periods were used in simple experiments designed to make the students familiar with their apparatus and some of the fundamental operations such as filtering, evaporating, pouring, etc. The glass work was also done during this time as well as some of the general experiments dealing with the text-book work being covered. We realize that our choice of the time to begin qualitative analysis is a rather radical departure from the usual practice, and for that reason we desire to tell others about it, as we have found it to be very successful.

A few words concerning some of the methods that we employ may be of interest.

A simple procedure is used and the students are required to analyze all unknowns without the use of their qualitative analysis manuals. This plan would not be possible with a more advanced procedure, but we believe that a simple procedure mastered is preferable to a complicated procedure half-mastered. This has the advantage that any tendency that the student might have towards becoming a cook-book chemist is not allowed to develop.

The analysis of the metals is completed in the early part of the second

semester and the usual unknowns are given for each group, followed by general unknowns. The same plan is then used with the acid radicals. General unknowns are then given, first in the form of solutions, and then in the form of solids, the latter being chosen so that they will give practice in the different methods for the solution of the samples. At least three commercial products are then analyzed. Among such products which are analyzed are cosmetics, medicines, proprietary articles, toilet and food products. Many manufacturers of such products have very kindly supplied us with samples. The following list will give some idea of the products analyzed: baby foods, baking powders, bath salts, deodorants, depilatories, face powders, face creams (cold creams, massage creams, astringent creams, etc.), hair tonics, inks, laundry bluing and tablets, non-perspirants, shaving creams, soaps and lotions, salves, soaps, talcum powders, throat tablets, toilet waters, etc.

In many cases the manufacturers supply us with the qualitative analysis of the inorganic constituents. In other cases we check the student's reports against our own analyses. We find that the students are very much interested in the analysis of such products and many of the students fairly eat them up, working four or five extra unknowns for extra credit. They begin to feel that their knowledge is something that can be used in the analysis of samples that have not been specially "doped up" by the professor. In other words, they begin to feel that they are chemists. This plan also serves to acquaint the student with the common inorganic ingredients in many different types of commercial products and stimulates a desire to know what ingredients should and should not be in a given product and how much it costs to manufacture it. This is one of the most practical ways that we have found of tying general chemistry up with everyday life. It is not hard to get a girl interested in the analysis of her favorite cosmetic or dentifrice.

Most of these products contain organic matter. At first we had the students destroy the organic matter according to the usual method, with, nitric and sulfuric acids, but this took a great deal of time in many cases and also caused a great deal of confusion at the hoods. We finally had the students use sodium peroxide. The sample of unknown was mixed with four or five times its volume of sodium peroxide and heated gently in a porcelain crucible over a bunsen burner until violent reaction ceased. Care was taken to protect the face against spattering during this operation. The mixture was then heated until it fused and the heating continued until the fusion became clear, more sodium peroxide being carefully added if necessary. The crucible and contents were then thoroughly cooled and dropped into a small beaker of cold water, taking precautions against possible violent reaction. The mixture thus formed was neutralized with hydrochloric acid and was then ready for analysis. Sometimes nitric acid

was used instead of hydrochloric acid where it seemed desirable. This meant that sodium and usually chlorine were introduced into the unknown. Special tests were made on portions of the original unknown for these two ions. It was often sufficient to ignite a portion of the unknown in a crucible over a blast-lamp and to dissolve the residue with water in order to make these separate tests.

When the class is about ready to begin the use of hydrogen sulfide in the laboratory we find that the following experiment is very useful in cultivating the correct attitude towards this gas. It results in a saving of the gas as well as in a proper appreciation of its poisonous qualities. A white rat is placed in a large beaker which is covered with a piece of cardboard, through which a tube leading from the source of hydrogen sulfide goes to the bottom of the beaker. A bubbling device is used to indicate the amount of the gas which is allowed to run into the beaker. A very small amount of the gas soon causes the rat to lie down and die without a struggle.

German Chemists Make Sugar from Wood. A process for manufacturing sugar out of wood, which Prof. Friedrich Bergius of Heidelberg University has worked out in the laboratory, has now reached a state where it may be utilized in industrial production on a large scale. A large factory to carry out the process is being erected near Geneva, Switzerland, by the International Sugar and Alcohol Company of London. It is estimated that an acre of forest land can be made to yield as much sugar as an acre of ground planted to sugar beets, and the new process has the advantage in that it can be carried out completely and continuously by machinery without the employment of the manual labor and the length of time necessary for crop production.

The synthetic sugar, however, is not the same as the sucrose made from beets or cane, but is rather like the glucose now made in America by the action of hydrochloric acid on corn starch. Glucose is not so sweet as sugar but is equally nutritious. The product of the Bergius process comes out in the form of a greyish powder, containing ninety-five per cent sugar. This can be used directly for cattle food or be purified for human use.

The process consists essentially in adding a molecule of water to each molecule of the cellulose of the wood pulp, which converts it to glucose. This is accomplished by treating sawdust with forty per cent hydrochloric acid in containers specially constructed of acid-proof and heat-proof materials. Earlier efforts to effect this transformation economically were frustrated because the acid was used in dilute solution, and afterwards, in driving off the excess of water, much of the sugar decomposed. In the present process the acid is recovered in concentrated form ready for renewed use without the expense of distillation. The necessary heat to evaporate the water from the mixture is introduced by the injection of hot vapors of mineral oil. This does not absorb the volatile acids and does not mix with the sugary solution, but floats as a layer on top and so can be easily separated. The oil is reheated and run in with more of the sugar cellulose solution.

The Bergius process for synthetic sugar was patented in the United States on July 28, 1926.—*Science Service*

THE SENSITIVITY OF QUALITATIVE TESTS

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The average student has little, if any, conception of the sensitivity of the tests commonly used in qualitative analysis. Though solubility tables are readily accessible, he does not seem to recognize them as a possible source of such information. Therefore, with the idea in mind of giving the beginner a tool with which he can quickly and easily determine the delicacy—especially the comparative delicacy—of a test under ordinary laboratory conditions, the following experiment was worked out and has been used with marked success in the author's classes:[1]

Put 1 cc. of $N/4$ silver nitrate in a 25-cc. graduated cylinder.[2] Dilute to 20 cc., then shake to mix thoroughly. Pour 10 cc. into a clean test tube. To this half add a few drops of hydrochloric acid. If a precipitate forms, dilute the part remaining in the graduate to 20 cc., shake, again transfer 10 cc. to a clean test tube and add hydrochloric acid. Continue diluting and testing until no precipitate is obtained. This is best determined by comparing the tested portion with 10 cc. of distilled water in a similar test tube. Hold the two tubes close together and look down through them from the top toward the bottom.

The data secured in this experiment may be put to a variety of uses, *e. g.*, the student may calculate (*a*) the quantity of silver in the last dilution giving a precipitate, (*b*) the quantity of silver chloride in the next succeeding sample. He may then compare this figure with the solubility of silver chloride as given in a table of solubilities. The numbers will probably not agree. Here is an excellent opportunity to bring up such points as: common ion effect, solubility of silver chloride in hydrochloric acid, carelessness in volume measurements, etc. A factor not usually considered in this connection is the effect of hydrochloric acid on the rate of precipitation of silver chloride, especially from a dilute solution. It may, for example, require hours to obtain maximum opalescence if ammonium chloride is used as the source of chloride ions, whereas with hydrochloric acid a much shorter time will suffice.

Perhaps the most important application of this experiment is to show the comparative sensitivity of various tests using the same ion. Students are astonished to find, after obtaining 10–12 dilutions with silver nitrate, that they get not more than one dilution when testing lead nitrate. The knowledge thus obtained is not quickly forgotten and no trouble is encountered in explaining the occurrence of lead in both Group I and Group II.

[1] The method is a modification of that suggested by Treadwell and Hall, "Analytical Chemistry," John Wiley and Sons, 5th English ed., 1921, Vol. 1, pp. 78–9.

[2] The silver nitrate may be dispensed from a buret, although the author prefers the use of a 1-cc. pipet.

Another opportunity to use the method comes when the confirmatory tests for iron are being considered. If five dilutions are obtained in the ferrocyanide test, then approximately fifteen will be obtained using thiocyanate, which corresponds fairly well with the published figures for the ratio of the sensitiveness of the two tests.

By suitable modification as regards determination of the end-point, the experiment may be applied to tests involving the formation of a precipitate, a change in color, or the evolution of a gas.

Sunlight Destroys Vitamins in Cod-Liver Oil. If the cod-liver oil bottle is allowed to stand too long on the bathroom window sill in the sunshine it is not nearly so worthwhile to make the baby swallow his daily dose. It will have lost its famous properties to make the young idea "grow big and strong," the inducement held out to down the oil that is an unappreciated part of the bill of fare of most present-day youngsters.

Dr. P. R. Peacock of the Middlesex Hospital has discovered that the growth-promoting vitamin A is destroyed by prolonged exposure to sunlight or to irradiation by ultra-violet light. He was led to make this discovery on finding that a bottle of cod-liver oil that had remained on his work-bench several months had lost its fluorescent properties when exposed to ultra-violet light.

Chemical tests failed to show the presence of vitamin A but the fluorescence returned when the bottle was kept in the dark, though the chemical tests for the vitamin continued negative. The "deluminated" oil, as Dr. Peacock calls it, was likewise proved lacking in growth-promoting powers when fed experimentally to rats.

Though the deluminated oil has no vitamin A, vitamin D, which prevents rickets, is quite unaffected by the action of ultra-violet light or sunlight.

A similar discovery has been made in the United States by R. W. Titus, J. S. Hughes, W. R. Henshaw, and J. B. Fitch of the Kansas State Agricultural College. They have found that ultra-violet light also destroys vitamin A in cow's milk.

This demonstrated instability of the growth-inducing vitamin, declares Dr. Peacock, makes it very desirable to pay careful attention to the way in which foods which owe their value to its presence are stored.—*Science Service*

Ancient Copper Believed Smelted by Petroleum. The most ancient copper used by man early in the dawn of civilization may have been smelted by the heat of petroleum, one of the most modern of fuels. This is the novel theory advanced by Percy E. Speilmann in a communication to the British scientific journal, *Nature*.

It was nature, rather than man himself, who arranged the smelting. Sir Flinders Petrie, the Egyptian archaeologist, recently discovered a remarkable similarity between the description of the Egyptian Paradise, described in the "Book of the Dead," and a region along the rivers of the Iora and Kura in the Caucasus. This is supposed to have been the original home of the Egyptians where they learned the working of metals, agriculture, and the writing of language.

In this area petroleum seepages, forming lakes in some cases, exist in close proximity to copper ore, and the theory is that the oil, accidentally fired, smelted the ore so that man coming upon the copper at a later date found it in metallic form.

The most widely accepted theory of the first smelting of copper is that primitive man accidentally brought ore and fuel together in his family campfire, thus becoming an accidental metallurgist.—*Science Service*

CHEMICAL EQUATIONS

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The complete but limited meaning of a chemical equation is frequently not understood by those who are not skilled chemists, and its significance is difficult to teach to the elementary student. As it is possible to put such a great deal of meaning in a few symbols set down with plus and equal signs, they are of considerable value as a method of expression of chemical ideas. Frequently, however, a great deal more meaning is assigned to them than it is possible for them to carry, and it is their limitations rather than their significance that are most frequently not appreciated.

To the student of elementary chemistry the chemical equation often stands for no reality but only a group of letters, figures, and signs. "(H) two (S) (O) four plus (Z) (N) equals (H) two plus (Z) (N) (S) (O) four" is frequently said and usually with as little meaning as the abstract letters themselves carry. The student saying this does not realize that not only is this not chemistry, but it is not true. Of course, part of the difficulty comes from talking in terms of symbols rather than substances. Besides this, zinc and sulfuric acids are not "equivalent to," but only under certain conditions will "go to form," hydrogen and zinc sulfate. There is a tendency to overcome this difficulty by using arrows in place of the equal sign. Another and perhaps the most subtle of the difficulties comes from the fact that the conditional quality of the equation is not sufficiently emphasized. The chemist knows that the equation represents a possible reaction, but that this takes place only under certain and sometimes very special conditions of temperature, pressure, solution, etc.; but the student is unaware of these limitations, which by the very nature of the equation cannot be written in it.

As it is necessary to write equations in order to appreciate the quantity relations of a reaction, the equation must be taught in elementary courses. If it were not for this, it would probably be better to leave out the symbolic representations until a greater appreciation of the experiments is obtained. The equation can be used as an excellent teaching medium provided its limitations are not lost sight of by the instructor; and it is not allowed to become a mere algebraic jumble in which the chemistry is lost in abstract mathematics.

Equations are used for two purposes. The first is to set down in symbolic form the expression of a chemical reaction, and the second is to establish the quantity relations of this reaction. As it is impossible to express the necessary conditions in a simple form, no attempt is made to do it. The quantity relations are obtained by a purely algebraic method that does not involve any chemistry. A knowledge of the experiment, which is what we are expressing, is absolutely necessary before the equation can be

written. This is one point where there is so much error. The student attempts to write the equation and, from it, reason what should happen in the experiment rather than doing the experiment and, from an observation of it, obtaining the substances to be set down in the equation.

The equation $nA + mB = rC + sD$ is logically read: "If n mols of A react with m mols of B there will be formed r mols of C and s mols of D." This does not say that they must react, but only that they have been found to do so under certain conditions by experiment, and that the products given were then formed. The coefficients are obtained by an algebraic method and the necessary conditions are not stated, as the conditional quality is understood. A very important point is that the mechanism of the reaction is not stated. It is found that, when A and B react, C and D are obtained. Just how this comes about is not expressed and in most cases we do not know. The problem of the mechanism of chemical reactions is a very difficult one and is by no means solved. With the advanced scientist in doubt we cannot expect the elementary student to be able to express just how a chemical reaction takes place. As far as the use of the equation is concerned it is sufficient to express the initial reactants and the final products as found from the experiment. It has been the practice of the teacher of chemistry to invent mechanisms for the elementary student that the student could not himself verify, and which were in most cases completely hypothetical. A good example of this is the $MnCl_4$ invented for the reaction of manganese dioxide with an acid chloride solution. Another example is the primary deposition of sodium in the electrolysis of an aqueous sodium chloride solution. Under the conditions which prevail when the student does the experiment these products are never formed and so, obviously, should not be assumed. For the teacher it will be found that it is sufficiently difficult and completely satisfactory from all points of view to express only the end-products of the reaction in an equation, leaving the questions of mechanism to the scientist.

The chemical equation can now be defined as a symbolic representation of a chemical reaction, with the molecular species reacting, in the molal ratio in which they react, set at the left of some symbol meaning "goes to form," and the products, in the molal ratio in which they are formed, on the right.

With the definition as the starting point, the essentials of the equation can be listed in the following manner:

1. It should contain those molecular species actually used up on the left of the sign meaning "goes to form" and those actually formed on the right. In the former example of the reaction of zinc and sulfuric acid it is quite visually evident that zinc, as such, disappears or is used up in the reaction. The formation of a gas is also visually evident and the gas is easily proved to be hydrogen. The acid property is also used up and this is in-

dependent of the acid used. This acid property is recognized as hydrogen ion and so this is one of the molecular species used up. Zinc sulfate is not formed, for we recognize that as a white solid, and no white solid is observed. This white solid would be a salt and as such would not exist in solution, for we are now fully convinced of the practically complete ionization of most salts in aqueous solutions. The exceptions to this are few and well-known. It is then zinc ion that is one of the molecular species formed. The equation $Zn + 2H^+ = Zn^{++} + H_2$ is then read, "if one mol of zinc reacts with two mols of hydrogen ion, there will be formed one mol of zinc ion and one mol of hydrogen." The same reaction would take place if a solution of hydrogen chloride in water were used in place of the dilute sulfuric acid and with the same heat effects, etc. The anion has not taken part in the reaction and so the equation is complete and experimentally true without it.

2. Only those species actually taking part or being formed should be included. In the above example the sulfate or chloride ion took no part; and so we would be violating our definition if we included them. It follows also that if a molecular species is written on one side of the sign it must not be written on the other, for the same species cannot be both used up and formed in the same reaction.

3. Molecular species which tend to react should not be placed on opposite sides of the sign. This, of course, can never be experimentally realized, but it is frequently seen in equations. The oxide of a metal reacts readily with hydrogen ion, but our texts will frequently write that the oxide of the metal is first formed when the metal is dissolved in dilute nitric acid. In this case we have the oxide of the metal on the opposite side of the sign to hydrogen ion and those react under the conditions of the experiment.

4. The quantity relations, that is, the molal ratios in which the molecular species react and are formed, should be expressed.

5. The equation should be completely balanced. The same number of atoms of each kind as well as the algebraic sum of the electrical charges when ions are involved should be expressed on each side of the equation.

6. The necessary conditions of environment or possible mechanisms are not expressed.

Before the mathematical work of balancing an equation can be done, it is necessary to assign valences. A set of arbitrary rules as given on the following page is of great help in doing this. These rules, although completely arbitrary can be used without exception and will assist in balancing the equation even if they sometimes assign unreasonable valences to some atoms. The rules, however, will represent the valences very nearly correctly. The term valence as used here merely signifies an assigned number for mathematical convenience and is not the best use of the term. It is not assumed that it corresponds to the technical term valence. It is used

because it is common practice to do so. If care be taken, however, it will correspond numerically. Any method of assigning valence will suffice, provided it is self-consistent. The method given is merely an easily workable one.

1. The valence of any element appearing alone except as an ion shall be zero.

2. The valence of hydrogen in any species except molecular hydrogen shall be +1.

3. The valence of oxygen except in molecular oxygen shall usually be —2. The peroxides are the exception.

4. The algebraic sum of the valences in any molecule shall be zero.

5. The algebraic sum of the valences in any ion shall be equal to the charge on the ion.

6. With the exception of hydrogen and oxygen and including oxygen in the peroxides the valence of an atom in a molecule or ion in which it occurs more than once shall not be taken individually. In this case the group of two or more atoms should be considered as one unit.

7. Valences may be assigned from previous knowledge or from chemical analogous reasoning, but of course there must be no inconsistency with the other rules.

Equations which do not involve oxidation and reduction are very simply and easily balanced. Oxidation-reduction equations are somewhat more difficult, although many simple equations like the reaction of zinc with acid come in this class. A method is here given for balancing these equations which is both simple and easy of understanding. It consists essentially of balancing one thing at a time and expressing that which is balanced on paper. The result is the elimination of the common fault of most methods of balancing such equations, which is the retracing of steps. To illustrate the method, the reaction of manganese dioxide with chloride ion in an acid solution will be balanced as the steps are presented. Before a start can be made in any equation the substances formed must be known from experiment. In this case they are chlorine and manganous ion. It will be shown that for reactions in an aqueous solution it is not necessary to know whether water is formed or used up. It will also be shown that it is not necessary to know whether hydrogen ion or hydroxyl ion is formed or used up. It is necessary to know whether the reaction takes place in an acid or alkaline solution. In the example given it is acid.

1. Write a small equation with one of the molecular species that has changed valence during the course of the reaction and with only the products formed from it on the other side.

In our example we will write

$$Cl^- \longrightarrow Cl_2$$

2. The small equation is then balanced with respect only to the groups changing valence.

$$2Cl^- \longrightarrow Cl_2.$$

3. Repeat step 1 with the other species that changes valences for oxidation and reduction are companion phenomena.

$$MnO_2 \longrightarrow Mn^{++}.$$

4. Repeat step 2 for this little equation.

No change.

5. Express the gain and loss in valence for each small equation, noting particularly that the gain and loss are expressed for the entire small equation and not for the individual atoms.

$$2Cl^- \longrightarrow Cl_2, \text{ gain } 2$$
$$MnO_2 \longrightarrow Mn^{++}, \text{ loss } 2.$$

6. Find the least common multiple of the gain and loss.

In this case it is two.

7. Make the gain equal the loss by multiplying each term in the small equations by the factor that will make the gain and loss equal the least common multiple.

In this case the least common multiple is 2 and the factor to use in the first little equation is one and that to use in the second is also one, so there is no change in our small equations.

8. Add the small equations.

$$2Cl^- + MnO_2 \longrightarrow Cl_2 + Mn^{++}.$$

9. Balance the charges. It is very important that this step be taken in this order. The charges are balanced by the use of hydrogen ion if the solution is acid, or hydroxyl ion if the solution is alkaline. They may come on either side of the equation depending on where it is necessary to place them in order to balance the charges. In an acid solution hydrogen ion may be formed, for it does not follow that, just because the solution is acid, hydrogen ion is used up.

$$4H^+ + 2Cl^- + MnO_2 \longrightarrow Cl_2 + Mn^{++}.$$

Note that the algebraic sum of the charges on both sides of the equation is now balanced at +2.

10. Balance the hydrogen by adding water to one side or the other.

$$4H^+ + 2Cl^- + MnO_2 \longrightarrow Cl_2 + Mn^{++} + 2H_2O.$$

11. Balance any other atoms except oxygen that have not yet been balanced.

In this case there are none.

12. Check the equation by counting up the atoms of oxygen on both sides, for if no mistake has been made they will be equal.

2 atoms on each side.

The substances have been balanced one thing at a time, first the chlorine, then the manganese, then the gain and loss in valence, then the charges, and then the hydrogen. The oxygen is all that is left and so it must balance, and the equation is complete.

All these steps must be taken in any method of balancing equations, but in many methods a step is taken tentatively and must be retraced after a future step is taken. This is obviated by the order given and by expressing each step as it is taken. If in any equation any of the steps are not needed, they are left out and the rest are taken in the same order. In most cases all the steps are not needed. Although twelve steps are taken, it has been found by the author that this method is much quicker than any other and much surer.

In order to illustrate further the method and also show the complete arbitrariness of the assigned valences, the oxidation of a solution of potassium thiocyanate with an acid solution of potassium permanganate will be balanced. Under the conditions of the experiment we assume nitrogen and carbon dioxide to be given off and the final solution to give a positive test for manganous and sulfate ions. For steps 1, 2, 3, 4, and 5 we have

$$MnO_4^- \longrightarrow Mn^{++}, \text{ loss } 5$$
$$2CNS^- \longrightarrow 2CO_2 + N_2 + 2SO_4^{--}, \text{ gain } 22.$$

All the coefficients are two except the nitrogen, for the equation must be balanced with respect to those things changing valence. We express nitrogen as N_2 and it changes valence. This causes us to take $2CNS^-$ and then $2CO_2$ and $2SO_4^{--}$.

The gain in valence for the second little equation can be arrived at in several ways. The simplest is to call the total valence of the CNS group, -1, and carbon in CO_2, $+4$, nitrogen in N_2 is zero, and sulfur in SO_4^{--} is $+6$. The total valence on the left is -2 and on the right $2(+4) + 0 + 2(+6) = 20$ or a gain of 22. We could by analogy assign the carbon in CNS^- as $+4$ and the sulfur as $+6$. The nitrogen must then be -11 in order that the sum be -1. This will make our small equation $2CNS^- \longrightarrow N_2$, gain 22.

Continuing balancing,

$$22MnO^- \longrightarrow 22Mn^{++}, \text{ gain } 110$$
$$10CNS^- \longrightarrow 10CO_2 + 5N_2 + 10SO_4^{--}, \text{ loss } 110.$$
$$\text{Adding, } 22MnO_4^- + 10CNS^- \longrightarrow 22Mn^{++} + 10CO_2 + 5N_2 + 10SO_4^{--}.$$

There are 32 negative charges on the left and 24 positive on the right. Add 56 hydrogen ions to the left and 28 water to the right, then

$$56H^+ + 22MnO_4^- + 10CNS^- = 22Mn^{++} + 10CO_2 + 5N_2 + 10SO_4^{--} + 28H_2O.$$

The oxygen balances with 88 atoms on each side.

To illustrate the case where there is more than one of a certain atom in a molecular species and also a reaction taking place in an alkaline solution, the oxidation of oxalate ion with alkaline permanganate solution will be balanced.

$$MNO_4^- \longrightarrow MNO_2, \quad \text{loss } 3$$
$$C_2O_4^{--} \longrightarrow 2CO_3^{--}, \quad \text{gain } 2.$$

The gain in valence in the second small equation is found by taking C_2 in the oxalate ion to be $+6$ and the 2C in the carbonate ions to be $+8$, which follows our rules for valence. Making the gain equal the loss and adding

$$2MnO_4^- + 3C_2O_4^{--} \longrightarrow 2MnO_2 + 6CO_3^{--}.$$

There are eight negative charges on the left and twelve on the right. Add four hydroxyl ions to the left and two water to the right.

$$4OH^- + 2MnO_4^- + 3C_2O_4^{--} = 2MnO_2 + 6CO_3^{--} + 2H_2O.$$

The equation is balanced with 24 oxygen atoms on each side.

The arguments advanced against the use of ions in equations are, first, that the sides of the equations do not come out electrically neutral, and the solution must be electrically neutral for physical reasons; and second, that salts are formed when the solution is evaporated. By the definition of the equation nothing was included about making the sides of the equation electrically neutral, but by doing so we would have to add the same thing to both sides of the equation, and this violates our idea of the simplest equation. We do not include the containing vessel nor the solvent and these are also physically necessary. Although solid salts are formed when the solutions are evaporated they are not present in the solution. If we evaporate the solution we are conducting a new experiment and this necessitates a new equation. The equation representing the crystallization of sodium chloride by evaporating a solution is

$$Na^+ + Cl^- = NaCl.$$

Of course, if a solid salt is formed by a reaction it is expressed as such in the equation.

The advantages of the use of ions in equations are very considerable. In the first place, they represent the molecular species as they actually exist to the best of our present knowledge. In the second place, they simplify our equations to a considerable extent. In the third place, after an appreciation of ions is acquired by the student, it makes the work much easier. In the fourth place, a visual inspection of the equation after it is written conveys more significance because it represents the actual phenomenon without hypothetical mechanisms.

The teacher will find that, although it is very difficult to get students who have used molecular forms to think in terms of ions, once they grasp it their work is greatly simplified. For the student who has not yet learned to use molecular forms, one way is as easy to learn as another. For this reason it is my opinion that ions should be included in the very beginning of chemistry at the same time that atoms and molecules are discussed.

The mere fact that chemical equations are included in a branch of science does not make them immune from a logical treatment. If a definition be made that will include all the properties that the equation can be allowed to carry and exclude all those that are inconsistent with its basic idea, certain salient features are brought out. Neither mechanism nor necessary condition of environment are included. The end-products only can be considered. The same term will be out of place in appearing on both sides of the equation as it would be in an algebraic equation. Only those molecular species actually taking part or being formed are represented, whether they be ions or molecules. The balancing of an equation is a mathematical process and independent of chemistry. The order of steps in the process is as essential as the order of steps in long division and the process is no more difficult. After a logical analysis it is found that equation writing is much more simple than is ordinarily assumed.

Dyestuffs Used to Make Better Rubber. Dyes and other organic compounds are now being used for prolonging the life of rubber as well as for speeding up the vulcanizing process in making the finished product from the sticky crude plantation rubber. Donald H. Powers, of Pennsgrove, N. J., described how the dyestuffs industry is thus helping the rubber manufacturer at the meeting of the American Chemical Society in Philadelphia.

"Organic compounds have been used as accelerators in vulcanizing rubber for the past ten years," Mr. Powers said, "but the dye industry is now furnishing some of the most widely used ones as well as developing newer and better ones. In addition, an organic anti-oxidant, a substance that slows up the aging of rubber, has been developed."

The world rubber situation will be profoundly affected when the secret of keeping rubber "alive" is solved. Rubber deteriorates fast on exposure to sunlight and under nearly all conditions to a varying extent. Chemists have been trying for years to find some substance with which to "dope" the rubber and keep it from aging too fast. A new substance put on the market by the dyestuffs industry, Mr. Powers says, is already prolonging the life of rubber many-fold.

Before the use of organic dyestuffs in rubber products only a few inorganic colors were available, Mr. Powers said. But now a wide variety of shades is used producing stocks of superior products and the dyestuffs industry is busy searching for new and still better compounds for use in rubber manufacturing.—*Science Service*

LABORATORY REPORTS IN BEGINNING CHEMISTRY*

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The teaching of the laboratory work in beginning chemistry seems to present some difficulties not so forcefully encountered in the case of more advanced classes. These difficulties appear to be due principally to the large number of short experiments usually performed in such a course. In general it is not found possible to grade the laboratory note-books thoroughly, accurately, and promptly and this in turn has a tendency to encourage carelessness in the keeping of laboratory notes. Sometimes students fail to write any notes at all and later on find it possible to make their records from a fellow student's note-book not only of experiments performed but, in frequent cases, also of experiments which they themselves have not performed. The inability of the instructor to grade the books promptly causes the work to become uninteresting and actually promotes inaccuracy and dishonesty.

Unfortunately we have no way of knowing definitely the laboratory attitude of the average student in beginning chemistry. However, it would probably be safe to venture an opinion that all too frequently the student has little or no interest in his laboratory work. He may even look upon this part of the work as a sort of hurdle over which he must jump or a kind of penance, handicap, or initiation. We believe that many students take this attitude for one or both of two reasons. In the first place the student may have come to the chemistry class without a thirst for knowledge and, as in the case of the proverbial horse, it is found difficult to make him drink. In the second place any desire for knowledge which the student may originally possess is not always encouraged under the usual conditions in the freshman laboratory. For example, if poor results are obtained because of mistakes about which the student does not know and which he is not required or helped to find, the work soon becomes uninteresting and unprofitable and the desire for knowledge may no longer manifest itself.

In order to stimulate the student's desire to know, as well as to avoid some of the other difficulties mentioned above, it has been found possible at the St. Louis University School of Medicine to modify the usual method of reporting freshman laboratory work in such a way as to make possible daily reports from each student and the careful inspection of each of these reports by the instructor. The advantage of daily laboratory reports in certain upper-class courses is quite generally conceded as, for example, in the case of quantitative or physical chemistry. The difficulty in requiring similar reports from freshmen is due largely to the greater

* Delivered before the Division of Chemical Education of the A. C. S. at Tulsa, April 7, 1926.

number of experiments performed and the larger number of students for each instructor. However, the advantages of having daily laboratory reports from freshmen should be the same as for any other course.

The Modified System of Laboratory Reports

At the beginning of the course each student is required to hand in one hundred blank debate cards six inches by four inches. The instructor places his initials in the upper right-hand corner of each card and retains them until required by the student. The student also provides himself with the usual form of bound note-book of any convenient size and style. When an experiment is performed he is instructed in the usual way to place in his note-book the object of the experiment together with a brief description of his procedure, his observations, and his summary or conclusions. He then calls the instructor's attention to his book before he has disposed of his experimental results. If the results and the note-book are found satisfactory the book is checked and one of the cards mentioned above is issued to the student upon which a brief summarized report is made. Although it is not possible to read everything written in the note-book, in the case of most experiments the instructor can satisfy himself concerning the nature of the work done in a very brief time. The note-book is checked with a grading pencil in order to prevent unscrupulous students from securing more than one card on the same written exercise.

The Experimental Results

If any part of the experimental results is found unsatisfactory the card is not issued until satisfactory results are produced. Also it is easy to see whether or not the student has recorded in his note-book the results of his experiment or the results described in the text-book or obtained by some one else. Any error can easily be pointed out, which is very profitable to the student.

The Card Report

The burden of obtaining the card bearing the instructor's initials is placed on the student and at the same time an excellent psychological effect is produced. Suppose, for example, that an important equation has been omitted from the note-book. All of the remainder of the work has been completed satisfactorily but no report can be made since no card is issued. Consequently the student at once sets about writing the equation and presents his book for a second inspection when he is given a report card if both the experimental result and the note-book are found satisfactory.

The mere fact that a card has been obtained does not, however, end the matter; cards must be written properly. The accompanying figures were made from student cards, with two exceptions as explained hereafter. The students were not informed of the proposed use of these cards and they

have been so chosen that the figures represent good, average, and unsatisfactory work. Figures 1 (*A*) and 1 (*B*) represent the front and back of a type card. The front of the card contains a statement of the object of the

FIG. 1.—(*A*) Type card; (*B*) Back of type card; (*C*) Satisfactory student card; (*D*) Unsatisfactory student card. Cards (*C*) and (*D*) were taken from the liberal arts and science class.

experiment which may frequently take the form of a question, and a brief statement of results. The back of the card contains a statement of the summary or conclusions. Card (*C*) on this same plate is a reproduction of a satisfactory card reported by a very excellent student. Card (*D*)

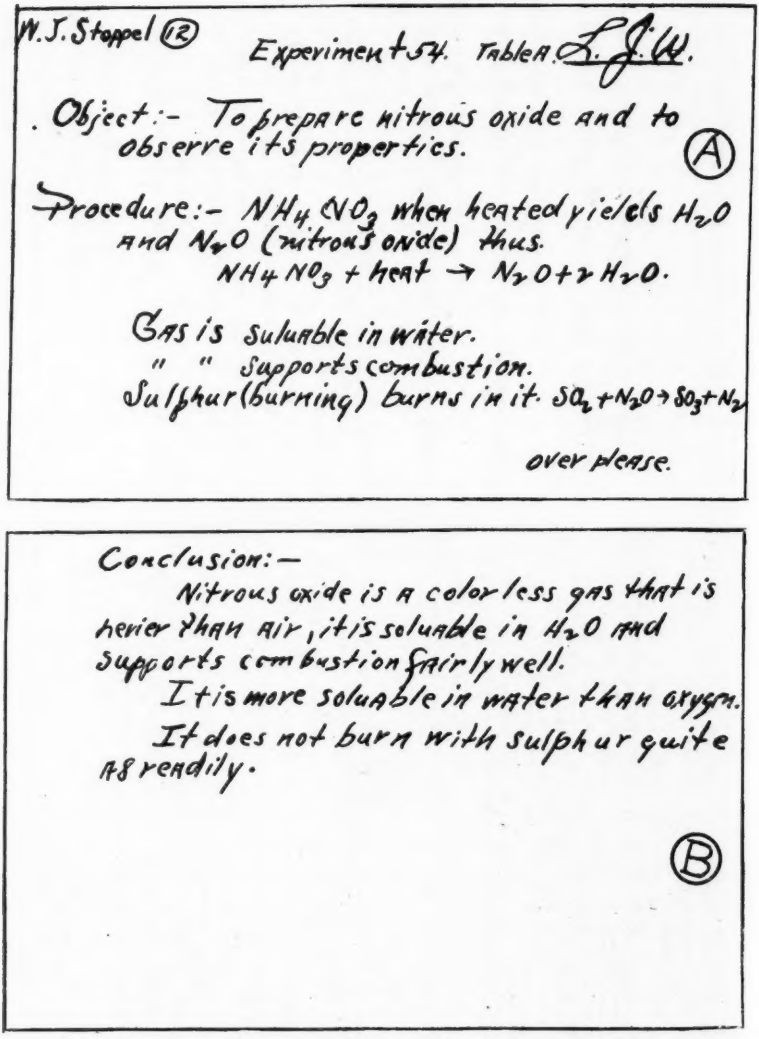
W. J. Stoppel (12) Experiment 54. Table A. L. J. W.
Object:- To prepare nitrous oxide and to observe its properties.
(A)
Procedure:- NH_4NO_3 when heated yields H_2O and N_2O (nitrous oxide) thus.
NH_4NO_3 + heat → $N_2O + 2H_2O$.
Gas is suluable in water.
" " supports combustion.
Sulphur (burning) burns in it. $SO_2 + N_2O \rightarrow SO_3 + N_2$
over please.
Conclusion:-
Nitrous oxide is a colorless gas that is heavier than air, it is soluable in H_2O and supports combustion fairly well.
It is more soluable in water than oxygen.
It does not burn with sulphur quite as readily.
(B)

FIG. 2.—(*A*) Satisfactory student card; (*B*) Back of card (*A*). By a student in dental class freshman chemistry.

was an unsatisfactory card reported by a good student whose work was generally satisfactory but who made a poor report in this particular case. Figures 2 (*A*) and 2 (*B*) show the front and back of a satisfactory card reported by a good student.

Each card is graded and handed back at the beginning of the next lab-

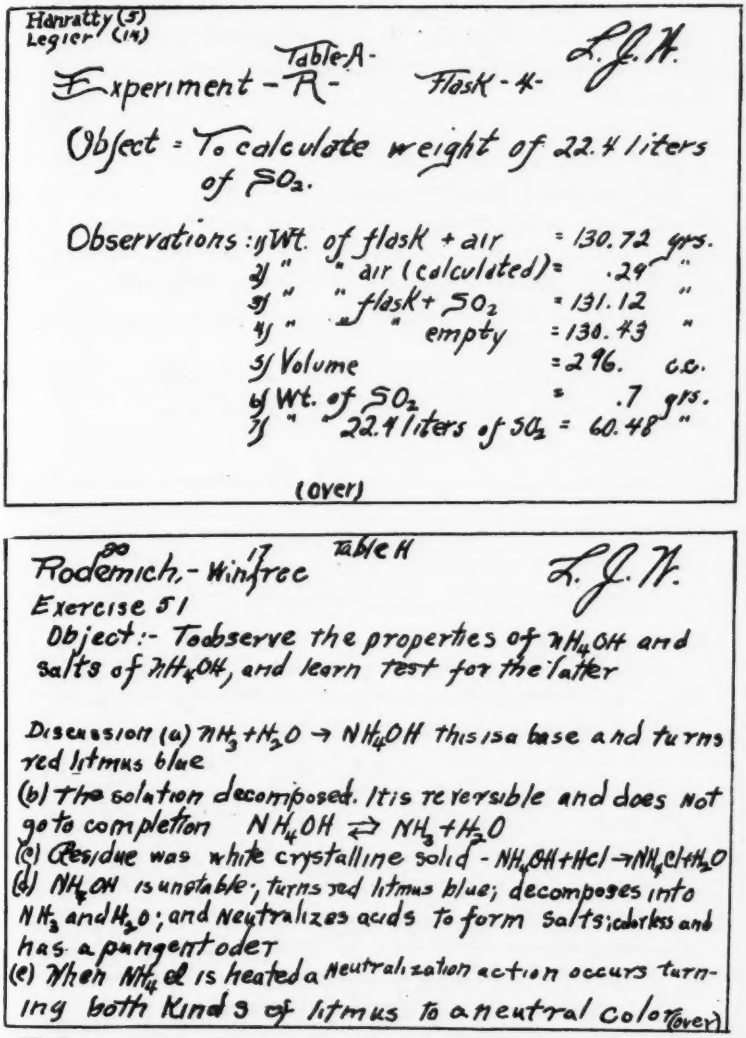
Hanratty (5)
Legier (14)
Table A
L. J. N.
Experiment - R - Flask - 4 -
Object = To calculate weight of 22.4 liters of SO_2.
Observations: 1) Wt. of flask + air = 130.72 grs.
2) " " air (calculated) = .29 "
3) " " flask + SO_2 = 131.12 "
4) " " empty = 130.43 "
5) Volume = 296. c.c.
6) Wt. of SO_2 = .7 grs.
7) " 22.4 liters of SO_2 = 60.48 "
(over)
Rodemich, - Winfree
Table H
L. J. N.
Exercise 51
Object:- To observe the properties of NH_4OH and salts of NH_4OH, and learn test for the latter
Discussion (a) $NH_3 + H_2O \rightarrow NH_4OH$ this is a base and turns red litmus blue
(b) The solution decomposed. It is reversible and does not go to completion $NH_4OH \rightleftarrows NH_3 + H_2O$
(c) Residue was white crystalline solid - $NH_4OH + HCl \rightarrow NH_4Cl + H_2O$
(d) NH_4OH is unstable; turns red litmus blue; decomposes into NH_3 and H_2O; and neutralizes acids to form salts; colorless and has a pungent oder
(e) When NH_4Cl is heated a Neutralization action occurs turning both kinds of litmus to a neutral color (over)

FIG. 3.—Two satisfactory cards from dental class.

oratory period, about one and one-half minutes being required for each card. If more time is required the card is not written properly and is returned to the student for correction. The statement of the object and the conclusion are parts of the cards to require most attention since

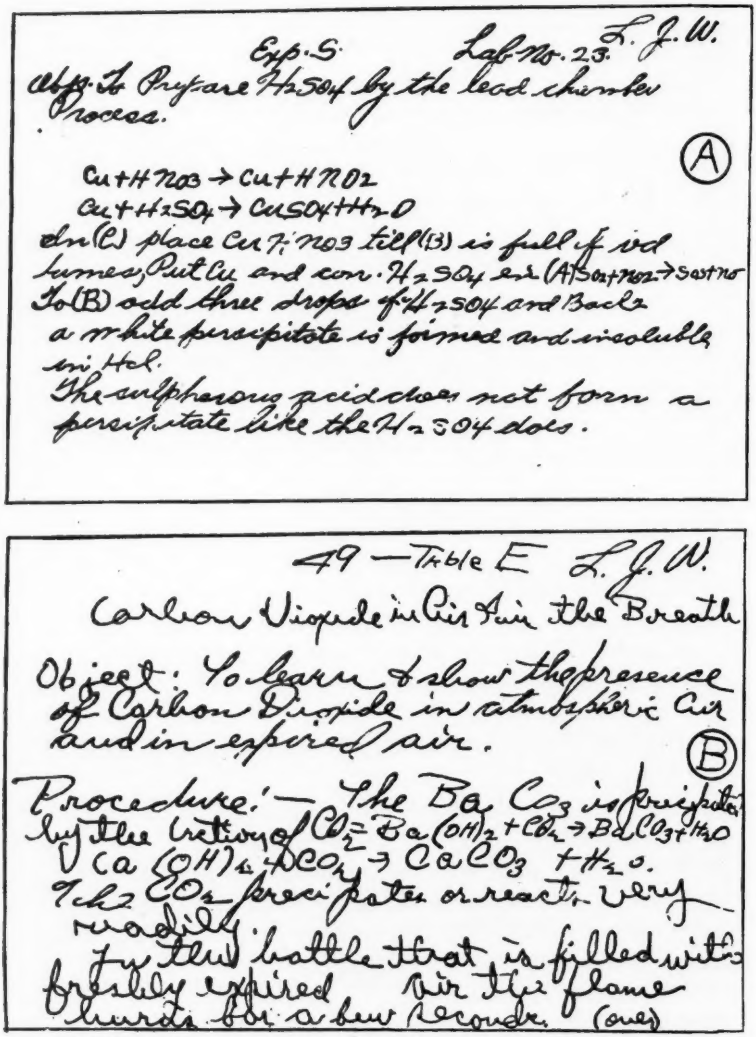
Exp. 5 Lab No. 23 L. J. W.
Obj. To Prepare H_2SO_4 by the lead chamber process.
A
$Cu + HNO_3 \rightarrow Cu + HNO_2$
$Cu + H_2SO_4 \rightarrow CuSO_4 + H_2O$
In (C) place Cu & HNO_3 till (B) is full of red fumes, Put Cu and con. H_2SO_4 in (A) $SO_2 + NO_2 \rightarrow SO_3 + NO$
To (B) add three drops of H_2SO_4 and $BaCl_2$ a white precipitate is formed and insoluble in HCl.
The sulphurous acid does not form a precipitate like the H_2SO_4 does.
49 — Table E L. J. W.
Carbon Dioxide in Air & in the Breath
Object: To learn & show the presence of Carbon Dioxide in atmospheric air and in expired air.
B
Procedure:— The $BaCO_3$ is precipitated by the action of CO_2 = $Ba(OH)_2 + CO_2 \rightarrow BaCO_3 + H_2O$
$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$.
The CO_2 precipitates or reacts very readily
by the bottle that is filled with freshly expired air the flame burns for a few seconds (one)

FIG. 4.—(*A*) Student card showing proper form but quite unsatisfactory. (*B*) Student card showing poor form. Both cards taken from the dental class.

the results are known to be satisfactory from the inspection in the laboratory.

Figure 3 (*A*) shows a satisfactory card reported by a couple of average students, card 3 (*B*) a satisfactory card reported by a couple of students, one of which was a very excellent student and the other a little better than average. Figure 4 (*A*) shows an unsatisfactory card reported by a very poor student. The card shows fairly good form but otherwise almost nothing can be said in its favor. Card 4 (*B*) was reported by a couple of average students.

Adaptation of Laboratory Assignments to Card Reports

In order to facilitate the card reports three types of experiments have been used, (1) descriptive experiments which produce results that can be preserved for inspection, (2) qualitative unknowns, (3) quantitative unknowns. Take as an example of the qualitative unknown type of experiment the determination of whether or not certain given water solutions will conduct electricity. The student who finds that a solution of sugar conducts a current of electricity (perhaps on account of a dirty beaker) frequently confers with some one else or reads in his text and finds that a solution of sugar should not conduct so he reports his observation as it should be and not as he saw it. Now it is undoubtedly very important for that student to know where he made his mistake. But the instructor cannot possibly see all of the conductivity tests made so he has no way of knowing of the mistake. However, if unknown solutions were issued it would then be necessary for the student to obtain correct results in order to secure a card for his final report. Also there is something about a qualitative unknown that usually arouses more interest than an ordinary descriptive experiment. The unknown determinations could well be followed by a series of conductivity tests on known solutions performed either by the class or on the lecture table.

As an example of the quantitative unknown type of experiment one of the first experiments of the course on the metric system might be mentioned. Instead of directing the student to measure his laboratory manual the size of which is the same as that of all the other students or asking him to weigh his match box, the weight of which the instructor does not know, a numbered wooden block of known dimensions and weight is issued to each one, along with a numbered vessel of known volume. The student must obtain correct results or repeat the experiment. If he really does not understand the metric system his case is almost hopeless if he proceeds without clearing it up.

Results Obtained

From October 1, 1925, to February 1, 1926, daily laboratory reports as described above were required in two freshman classes. The first

class was a class of dental freshmen of 62 members, the second a class of men studying liberal arts and science, containing 35 members. Two laboratory instructors and a storekeeper were provided for the arts and science class and three laboratory instructors and a storekeeper were provided for the dental class. The author of this paper had the direction of both the class-room and laboratory work of both of these classes.

The dental class performed 29 experiments during the four months period, a total of 1798 experiments due from the whole class. At the end of the semester all but 39 experiments were complete or 98 per cent. The arts and science class performed 32 experiments or a total of 1120 experiments due from the whole class of which all but 16 were complete, the per cent of completed experiments being 98.6. In the dental class 25 of the 39 experiments uncompleted were due from 4 students two of which dropped the course at the end of the semester. In the arts and science class 13 of the 16 uncompleted exercises were due from 3 students. Furthermore throughout the semester, seldom was a student more than one or two experiments behind the laboratory schedule and the note-books were of necessity kept written up to date.

Advantages

The most obvious advantage but perhaps one of the least importance is that the instructor is assured that practically all of the laboratory work reported was actually performed by the student making the report and not copied from someone else. Other important advantages have been found to be

(*a*) The note-books are kept written up to date in almost one hundred per cent of the cases.

(*b*) Better note-books are kept, since a summary must be placed on the report cards.

(*c*) The student has a daily report of his work.

(*d*) The manner of obtaining the report card has a good psychological effect.

(*e*) The pointing out of mistakes both in experimental results and in the note-book is facilitated.

(*f*) Less time is required for grading the report cards than would be required for carefully grading note-books.

Les Laboratoires sont les temples de l'avenir, de la richesse et du bien-être; c'est là que l'humanité grandit, se fortifie et devient meilleure.—PASTEUR

LECTURE TABLE DEMONSTRATIONS OF THE NATURE OF CONCENTRATED SULFURIC ACID*

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The progressive dissociation of a salt upon the gradual addition of water to its concentrated solution is rendered visible in the case of cupric bromide by the difference in color of the undissociated molecules and that of one of its ions. The conversion of undissociated 96% sulfuric acid, inactive toward metals, into the active dilute acid may be similarly rendered visible by the aid of an indicator. Dimethylaminoazobenzene is red in aqueous solutions in which the hydrogen-ion concentration is greater than 10^{-3} to 10^{-4}, and yellow in solutions in which the hydrogen-ion concentration is less.

The addition of a few drops of either a red or a yellow aqueous solution of this indicator to 10–50 cc. (depending upon the size of the lecture room) each of normal hydrochloric acid, normal sodium hydroxide, and 95–96% sulfuric acid solutions causes the appearance of red, yellow, and yellow colors, respectively. The similarity in the color of the alkaline and concentrated acid solutions indicates the probability that the concentration of hydrogen ions in the 96% acid is less than 10^{-4}. (It is true that the effect of changing the medium about the indicator from water to sulfuric acid may alter in some unknown manner the inversion point of the indicator. However, this does not affect the validity of the conclusion drawn from this demonstration, since, in that, no attempt is made to determine the actual hydrogen-ion concentration of the sulfuric acid.) The addition of an equal volume of water to the yellow solution in concentrated sulfuric acid changes the color to red, showing that the water has induced the dissociation of enough molecules of H_2SO_4 to provide a hydrogen-ion concentration greater than 10^{-3}. On the further addition of sodium hydroxide solution, the color again becomes yellow. The indicator has not been destroyed by the strong hot acid.

This behavior is not peculiar to this indicator; methyl orange, methyl red, and many others may be substituted. Congo red is, however, unsuitable.

A further experiment may serve to show that the water required for the completion of the ionization process may be derived from varied sources. To a solution of a few drops of methyl orange solution in 25 cc. of sulfuric acid is added 10 cc. of water; it is readily apparent that the further addition of a small amount of water will produce a red color, although yellow still predominates. This solution is then divided into four separate beakers, the first of which is reserved for comparison. To the second is gradually

* This paper is based upon one presented by the author before the Cincinnati Section of the American Chemical Society in March, 1922.

added from three to five grams of anhydrous sodium carbonate. The color becomes red because of the dilution of the solution by the water formed in the reaction. The careful addition to the third beaker of a stick of potassium hydroxide about 4 cm. long results in a vigorous reaction during which the solution becomes red. This experiment, in which the usual color change in a neutralization reaction is reversed by carrying it out at a concentration different from that ordinarily employed, and in which the acidity of a strong acid is made manifest only upon the addition of an alkali, suggests an analogy with the biological process of immunization, which, like this, occurs in a system containing relatively little free water. To the fourth beaker is added 4 grams of fused sodium acetate. For a time there is no reaction; if the beaker is heated, acetic acid is slowly evolved and the color of the solution becomes red. In this case it is not the diluting action of water, but the actual reaction of the acetic acid produced, which is demonstrated. That this is the case may be shown by adding a few drops of methyl orange to glacial acetic acid; an intense red color develops. The addition of a very small amount of water to the "weak" 100 per cent acetic acid suffices to produce an acid reaction toward methyl orange, while, because of its tendency to bind water as hydrates, a very much greater quantity must be added to the "stronger" sulfuric acid to produce the same reaction. The quantities employed in the above experiment may be increased indefinitely, provided that approximately the same relative amounts of reagents are used.

Summary

Experiments are given in which the dissociation of sulfuric acid is followed by means of indicators. A lagging of the dissociation behind the dilution serves to demonstrate the power of sulfuric acid to bind water as hydrates.

The following references may serve to throw light upon the theory involved.

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H. C. Jones, *Z. physik. Chem.*, **13**, 419 (1894).
Miles and Fenton, *J. Chem. Soc.*, **117**, 59 (1920).
V. Čupr, *Rec. trav. chim.*, **44**, 476 (1925).

The task of an investigator requires for its success the toughness of a soldier, the temper of a saint, and the training of a scholar.—HUMPHRY DAVY

Correspondence

ITALIAN LETTER

Generally speaking those outside Italy have little opportunity to hear about the developing chemical activity of our country and perhaps those interested in chemical progress have not a very good opinion of our schools and methods. Really, Italy has for centuries produced men famous in the realm of physical science: Torricelli, Galileo, Cannizzaro. For the moment no great chemical industry has been established in Italy but chemical activities extend in every direction and the future, only, can show which will become the one of greatest national importance. It is well known that our country has no mineral resources except in small quantities, nor any colonies from which to get them; so if we have good factories of pharmaceutical products they only specialize in Galenical preparations. I have mentioned the conditions of chemical industry in Italy at present because generally the activity of any country in a special branch of work is seen through the products and we only have a small production of alkaloids, dyes, synthetic preparations, etc. The chief reason for that is our poverty in the principal minerals, iron and coal, which always form the base of any industry. I have to say now that in the last two or three years all the activities of the country were encouraged and enlarged by the new government; so also in the chemical works we can see that they are making great strides especially in Northern Italy, where considerable improvements have been and are being made principally owing to the facility to get huge quantities of electrical power for the Italian Alps. White coal! "Carbone bianco" as we call the water power, will be in a few years almost a complete substitute for real coal; and I think we have now the biggest electrical stations in Europe and will have more in the future.

However, we produce where we are able to do so and, for example, from the fruits of Sicily we make considerable quantities of essential oils and citric acid. The mines of Tuscany furnish material for the preparation of all the salts of mercury, antimony, and some of copper. From the mountains of Puglia, which are very rich in bauxite, considerable quantities of aluminum are extracted by a new method (of which I will speak on another occasion) of Prof. Blanc, member of the Italian Parliament. The artificial silk industry, then, one of the latest phases of Italy's commercial activity has made such rapid progress during the last few years that Italy now holds second place in the world (after America). Up to a few months ago the bulk of the raw cellulose used in the production of silk was imported, but the erection of a factory at Naples now producing fifty per cent of the total

quantity used, is a step tending to the establishment of an industry independent of foreign support. The center of the silk industry is in Turin and employs a capital of a million lire (Italian).

I have shown briefly the most important parts of chemical activity at the present moment. It may seem very little, but I think, given political stability, more will be done in the future for the development of promising industrial activities.

ROME, ITALY PAOLO CALZOLARI

GAMMA SIGMA EPSILON

(An Honorary Chemical Fraternity)

During the last few decades there has gradually developed a distinct tendency among the college students of this country to devote a considerable part of their time to extra-curricular activities. In order to make their untiring efforts more fruitful and enjoy the fellowship of each other, students of similar academic interests and tendencies have grouped themselves into organized literary, scientific, and professional societies. School authorities, considering the direct and indirect benefits derived by the institution and the individual student from such activities, have generally encouraged students in that direction.

As a result, today there is a multitude of student organizations in every college, each working toward a definite aim. Some of these are distinctly social, some others are academic, while still others combine both characteristics. These societies are not always confined to one particular college. They constitute, in many cases, branches of wider organizations. The national character of a society, or fraternity as it is frequently called, makes it more attractive to the average student.

The Gamma Sigma Epsilon chemical fraternity is one of the honorary college societies of the country. A brief presentation of its history and aim might be of interest to the readers of the JOURNAL OF CHEMICAL EDUCATION.

Gamma Sigma Epsilon was founded in 1920 in Davidson College, Davidson, North Carolina, by a group of students, under the guidance of the Department of Chemistry. These students had long felt the need of fellowship and closer contact between the advanced chemical students of the college. Soon chapters were established in other institutions of higher learning, the Davidson chapter having the unique honor of being the mother-chapter of the organization. The government of the fraternity became vested in a Grand Council; biennial conventions have since been held regularly. The chapters are located at Davidson College, Uni-

versity of Florida, University of Alabama, North Carolina State College, Johns Hopkins University, Alabama Polytechnic Institute, and Wake Forest College.

The individual chapters hold their meetings regularly at least twice a month throughout the scholastic year. The program includes the reading of papers by members on topics not treated in class. Occasionally open meetings are held to promote interest in chemistry among students not affiliated with the fraternity. Some chapters contribute to the cause of the science of chemistry by offering a medal to the freshman obtaining the highest grade in general chemistry. Honorary members selected from the faculty take a keen interest in the welfare of the fraternity and play an important rôle in its progress.

Regular members are elected with great care from among juniors and seniors intending to specialize in chemistry. Admission is based upon scholastic attainment in chemistry, good character, and sociability. It is the policy of the fraternity to keep its standard high, so as to make it a real honor for a student to be elected to membership in Gamma Sigma Epsilon.

To the best of the writer's knowledge, this fraternity is the only one of its kind in the country, since its membership is open primarily to undergraduate students, and since it is an honorary rather than a professional or semi-social organization. Although at first somewhat conservative, Gamma Sigma Epsilon now favors the establishment of a few more active chapters in the leading colleges and universities of the country.

The progress of this society within the last few years has been marvelous. Gamma Sigma Epsilon, although young, is full of vigor and looks with great enthusiasm to a still brighter and more glorious future. Any information in regard to the fraternity may be obtained from one of the following national officers: J. M. Appleby, Davidson College, Davidson, N. C.; H. D. Jones, Auburn, Alabama; Z. M. Pirenian, University of Florida, Gainesville, Florida.

UNIVERSITY OF FLORIDA
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Z. M. PIRENIAN

Cotton from Wood Is Hope of Chemists. The boll weevil, the bane of southern planters and northern congressmen alike, will be out of a job and have no place to go if the efforts of scientists to make a soft downy cotton from hard fibers of wood are attended by success in the future. Gustavus J. Esselen of Boston told the American Chemical Society of the efforts of chemists in their search for new sources of cellulose raw materials and of the possibility of obtaining from wood a cellulose similar to that of cotton. Untold possibilities in the future development of the textile trade may result, Mr. Esselen said, from the application of cellulose chemistry to the industry.—*Science Service*

Chemical Digest

CAN EDUCATION INCREASE INTELLIGENCE?

The much mooted question of increase in intelligence through education is again made the point for discussion in a recent number of the *Forum*[1] Dr. William McDougall, as his title, "Mental Capacity Fixed at Birth," implies, is of the opinion that education does not increase intelligence. He says:

> Attendance at a good school disciplines the character, imparts respect for persons, institutions, and ideals, and teaches the art of getting on with our fellows. Further, it is the best way yet devised for securing to children *en masse* a vast amount of knowledge and skill, including those three most useful arts, reading, writing, and arithmetic, without command of which no man is fit to take his place as a citizen of a modern State. And the art of reading, thus acquired, is the indispensable means to the acquisition of an indefinitely great mass of other knowledge, historical, scientific, and literary. Education, then, brings immense benefits; and a public system of free schooling is indispensable in the modern State. But, recognizing all this, we may still be in doubt as to the answer to our problem—Can education increase intelligence?

We might hope for some consensus of opinion in the matter, according to Dr. McDougall, if we could find some generally acceptable way of defining intelligence. "Intelligence is what the intelligence tests test" is about as close as we have come to a real definition. Speaking of the various views as to the meaning of the term, Dr. McDougall says:

> Such speculations are of great theoretical interest; and some day perhaps we shall be able to define intelligence more confidently and more exactly. In the meantime we have only opinions, founded in the main on common observation of human life. And in my opinion the best opinion is that according to which intelligence, in the strict and narrow sense of the word, is not increased appreciably by education. If we use the word "intelligence" in a large and loose sense to cover all that contributes to render a man well fitted for the battle of life, all knowledge and all skill, then of course education does increase intelligence. But "intelligence" so used is a word that obstructs, rather than aids, clear thinking. Intelligence is that factor which is displayed most clearly in the acquisition of knowledge and skill, and should not be identified with these products of its operation. There does seem to be some factor, or more probably several factors, of our inborn constitution, which in each man may play a principal rôle in determining the degree of ease with which he acquires knowledge and skill, and also the effectiveness with which he makes use of the knowledge and skill already acquired. And though it may be true that all our functions, including our intelligence, require exercise for full development, there seems little reason to suppose that formal education of any kind can promote the development of this particular function more effectively than does the ordinary course of daily life in home and field and forest, in factory, and workshop.

[1] "Can Education Increase Intelligence?" William McDougall and I. A. Richards, *Forum*, **76**, 498–509 (Oct., 1926).

Dr. I. A. Richards takes for his subject, "But We Can Be Taught to Think" and writes:

Very nearly all the important questions of psychology have, at present, to be answered in the same way—"Sometimes—sometimes not." Sometimes education does increase intelligence (in the only sense in which it is profitable to use the word) sometimes it does not, sometimes it may even decrease it. This is not nearly so dull or so disappointing an answer as it looks; all our knowledge has come about through just such answers, for they bring us down out of the clouds of verbal and abstract speculation which we so much enjoy. They deflate us, which is, perhaps, why we dislike them.

After all "Education" like "Aspirin," "Chippendale," or "Literature," is only a label which guarantees nothing about the precise nature of the thing which is sold or handled under it, and it is only in view of this precise nature that we can usefully discuss the matter. There are myriads of educational processes; no two teachers have exactly the same influence upon their pupils; no two families grow up in the same educational circumstances....

Dr. McDougall and Dr. Richards disagree mainly in their use of the word "intelligence." In presenting the subject under discussion they swerve away from it to contention over the true meaning of intelligence. Again quoting Dr. Richards:

"Intelligence" even in the stricter sense in which Dr. McDougall uses it, is a word which wrecks the whole discussion. One man acquires skill and knowledge more easily than another. He handles new situations better than the other, and we can say he has more "intelligence" if we wish to point out this observable fact. This is the only use we should make of the word if we are not to be the victims of verbal abstractions. But if we shift the word from this use, as almost all psychologists do, and make it the name of a supposed factor, or small group of factors, which *explains* this superior capacity, or *is displayed* by it, we are assuming a quite hypothetical extra entity, something which may not and probably does not exist at all, something which we cannot observe. We go on to discuss this supposed something regardless of the fact that its origin is in a linguistic convenience.....

Dr. McDougall admits the great importance of pre-school years in the development of character while denying it for the development of intelligence. But this distinction between character and intelligence, though popular and useful for some purposes, is a very doubtful affair. Neither Plato nor Aristotle would have thought much of it. Is it not likely that some of the main factors governing intelligent behavior are to be found in character? There are such things, for example, as intellectual diffidence and intellectual audacity. Often what we call stupidity is merely panic at the sight of the new. More often still it is a legacy left by early bewilderment and indecision. The impulse of curiosity, the impulse to "try for oneself" rather than to wait to be shown, the impulse to lead in mental experiment rather than to follow passively, all the varying degrees of self-reliance with which we meet the unfamiliar, all these belong to the sphere of character. And who will deny that they are of immense consequence in determining whether our conduct shall be intelligent or not?

Dr. Richards concludes thus:

If we get rid of the notion that "education" means a single influence like a trade wind blowing in a single direction, and if we are on our guard against "intelligence" as the

name for an abstract "faculty," we shall see abundant reason to think that the difference between able and stupid persons is to be explained by the early accident of their lives rather than by an inborn unchangeable endowment.

W. R. W.

SCIENCE IN PRACTICAL AFFAIRS

The search by the Government for domestic supplies of potash of sufficient extent to render the United States independent of foreign producers of this essential material will commence in Uptown County, Texas. This area, which has been recommended by the United States Geological Survey for potash exploration, is located in a territory now developing as an oil field, oil production being obtained at an average depth of 2000 feet. The depth to the top of the potash-bearing salts is 435 feet. The enabling act authorizes the expenditure of $100,000 per annum during a period of five years, to be expended by mutual agreement of the secretaries of the Interior and Commerce for the purpose of determining the location, extent, and mode of occurrence of potash deposits in the United States, and conducting necessary laboratory tests.

Nearly $15,000 has been raised for the establishment of a research bureau for the scientific investigation of vital problems of the drug trade. The proposed bureau will operate as a national clearing house for the investigation of facts, figures, and information pertaining to all branches of the drug industry. An investigation of the actual value of window displays, and a test of the individual selling ability of retail and clerk members were two researches suggested for the bureau's first year. It has been proposed that the bureau be located in New York City and controlled by a committee composed of representatives from the National Wholesale Druggists Association, the National Association of Retail Druggists and the American Association of Colleges of Pharmacy.

The average hydro-electric installation is five and one-half times as efficient as the average steam plant but, according to A. H. Horton, chief of the Power Resources Division of the U. S. Geological Survey, the greater cost of construction of the water power unit offsets this advantage, and the cost of producing hydro-electricity is not lower than the cost of fuel generation. The average efficiency of fuel-burning public utility power plants is about 12½ per cent. That is, for every 100 horsepower in the coal

consumed in generating power only $12^1/_2$ horsepower is made available for use. The efficiency of a water power plant is about 70 per cent. The increasing efficiency in utilization of fuel in public utility power plants is making it more and more difficult for hydro-electric power to compete with power produced by the use of fuel.

Gas companies are selling larger quantities of their product today than at any other time in the history of the industry, according to the New York Commercial. Research has been of immense value in this field and has been undertaken by the American Gas Association and the engineering staffs of individual companies. The investigations have brought out the fact that there are now 10 major uses for gas in the average residence in contrast to the single use, lighting, 50 years ago. Evidences of the rapid strides being made in the consumption of gas are seen particularly in Chicago and Baltimore. In the former city gas sales during the past 15 years have increased 78 per cent although the population has increased but 38 per cent. During the last heating season 1300 Baltimore homes were heated entirely by gas with a total fuel consumption of 700,000,000 cubic feet. Gas thus replaced 20,000 long tons of anthracite coal, which would have required 6667 three-ton trucks for original haulage and a proportional number for the disposal of the resultant 2000 tons of ashes.

Practically all the iodine manufactured in Japan is derived from seaweed which is everywhere abundant along the coast line. In various places the kelp is gathered and burned for the iodine and chlorides of potassium and sodium contained. The methods of manufacture are kept secret but investigation shows that no improvements are in vogue over the ordinary methods used in France, Scotland, and Norway. As practiced in Japan there is no doubt that there is a considerable loss through crude apparatus and manipulation. The cost of production is about 5.50 yen per pound. (1 yen equals 50 cents, approximately.)

Professor Paneth and Dr. Kurt Penters of Berlin University have announced that they have discovered a method of manufacturing synthetic helium from hydrogen. Although only an infinitesimal quantity has been produced by their method so far, the chemists will pursue their experiments hoping to manufacture the gas on a scale which would permit Germany to inflate dirigibles with non-explosive helium instead of explosive hydrogen.

A research institute in the dyeing and cleaning industry is now under construction in Washington, D. C. It is to be called the Institute of Dyeing and Cleaning and is to be patterned after the laboratory erected by the laundry industry in Joliet, Ill., and known as the American Institute of Laundering. The Institute will coöperate with the Bureau of Standards in the testing of textiles and dyes and there will be facilities for training 300 students a year. An encouraging feature about the movement is that the $125,000 needed for construction of the laboratory was subscribed by members of the National Association of Dyers and Cleaners and control of the plant will be in the hands of ten members.

Until recently the only cocoa by-product in this country cheap enough to be of interest to the fertilizer industry was the shells, with such related waste material as cocoa dust and sweepings. As a result of the enormous demand for cocoa butter, two additional by-products of importance are now being produced in large quantities and they have been obtainable at prices which have made them available for use as fertilizer materials. These are the cocoa press cake and the solvent-extracted cocoa. The latter is the defatted residue left after extracting the cocoa fat from the press cake with benzol. Department Bulletin No. 1413-D gives a report of an investigation as to the nature and value of cocoa by-products as fertilizer material. A copy of the bulletin may be obtained free by writing to the Department of Agriculture, Washington, D. C.

By the introduction of a gas within the mass consisting of cement and aggregates of any kind or texture commonly used in producing concrete, physical effects are produced similar to those effected by yeast in the making of bread. This occurs before the initial set, by which time concrete has taken on a cellular characteristic, wherein K. P. Billner, of A. B. Vallevikens Cement-fabrik, Sweden, sees possibilities of greatly reducing American building costs. Concrete made under this process gives bulk and at the same time lightness of weight, thus making it possible to cut down the quantity of supporting steel.

An educational trend of national importance is training in engineering subjects. Whereas colleges of liberal arts existed in the United States early in the 18th century, it was not until 1824 that our first engineering college, Rensselaer Polytechnic Institute, was established at Troy, N. Y. The original course of engineering instruction in this institution was of

only one year's duration but, following the French practice, it was lengthened to three years in 1849. Lawrence Scientific School at Harvard and Sheffield Scientific School at Yale were established in 1847 and in the same year the University of Michigan started its school of civil engineering. These were the sole engineering courses in the United States prior to the Civil War. By 1870 there were 17 state colleges as compared with four in 1862. In 1871 there were 41 engineering schools for departments of liberal arts universities and in 1880 the number had increased to 85. Problems with which business executives are now faced are so complex and so closely associated with engineering problems that technical training is fast becoming almost as essential as knowledge of ordinary business management.

Winter Sap of Evergreens Too Thick to Be Frozen. Why do the leaves of evergreens hang on all winter long, when by rights they should be frozen and drop off? According to researches of Dr. Floyd W. Gail of the University of Idaho, reported in the current issue of the *Botanical Gazette*, they stick because in winter their sap becomes too thick to freeze.

Dr. Gail gathered leaves from pine trees and from broad-leaved evergreen shrubs once every month through three years, crushed out the sap and tested it for its freezing point. He found that during the summer when the weather is warm and the sap flows freely that it is relatively thin and could be frozen easily if there were any frost to freeze it. But as Fall comes the starch in the leaves is converted into sugars and oil, changing the sap from a thin and watery fluid into a sort of syrupy emulsion very difficult to freeze. He found that the greatest density of the sap was reached during late January and February, when the most severe freezing weather occurs. Deciduous trees that lose their leaves in autumn show some thickening up of the sap, but apparently the sugars are transferred into the tree before the leaves drop off, for Dr. Gail found that the sap pressed from leaves that had just fallen was easily frozen, whereas sap from leaves not quite ready to fall resisted the effects of considerably lower temperatures.—*Science Service*

Revision of State Laws May Help Tobacco Planters. Chlorine injury to tobacco from certain prohibited fertilizers is over-estimated and many state laws are only a hindrance to planters in the opinion of F. B. Carpenter and A. H. Allen of Richmond, Va., who spoke before the meeting of the American Chemical Society in Philadelphia.

Experiments have shown that muriate, which is banned as a tobacco fertilizer, produces a larger yield and a better quality of tobacco, as far as market value is concerned, than sulfate, which is widely used. As the leaf, however, will then contain more chlorine and may tend to produce an inferior burn, Mr. Carpenter suggests that the best results might be obtained by using muriate and sulfate in proper proportions, thus retaining the high yield and better quality without the excessive chlorine.

A number of popular brands of cigars, ranging in price from two for a nickel to twenty-five cents, as well as commercial smoking tobaccos, pipe tobaccos, and cigarettes, were tested for chlorine. Mr. Carpenter stated that cigars contain more chlorine than is generally supposed and that the average smoking tobacco contains less than cigars. Much chlorine is not desirable, but tobacco can stand a good deal before it burns badly, and it seldom contains enough to do serious harm.—*Science Service*

ABSTRACTS

The Contract Plan of Assignment and Some Implications Concerning Procedure. H. I. MILLER. *Educ. Adm. and Superv.*, **12**, No. 4, 238–50 (1926).—A type of assignment known as the Contract Plan of Assignment is advocated as one of the most effective devices for giving individualized instruction. A larger unit than that of the daily lesson is contemplated and within this unit provision is made for individual differences by arrangement of materials about a core of ideas or principles with certain specific challenges or contracts to stimulate all pupils to work up to capacity. Too much time is now spent in "listening in" and too little in real thinking. The contract plan emphasizes individual differences. Each pupil is given a contract calling for the completion of a certain piece of work in a definite time. A minimum completion of the contract means a passing grade. Completion of extra work in addition to minimum called for in the contract means a higher grade. The lowest block of material should embody the fundamentals. The second and third blocks should embody work of a more difficult nature, involving more thinking and analyzing. In this plan the teacher becomes the guide who directs and stimulates the mental life. Team work, group activity, competitive productions, individual presentations result. A wider and more sure-footed scholarship is provided for, not one based on mere information. The student becomes a participant rather than a recipient. S. R. P.

The Next Step in Higher Education. HUGH E. WILLIS. *Sch. and Soc.*, **24**, 217–26 (Aug. 21, 1926).—The important question in education today is, what is the purpose of higher education? U. S. educational history shows 3 periods: (1) the classical, (2) the elective, (3) period of student activities. Thoroughness was a characteristic of the classical period and its product was a cultured gentleman. Because of its limitations it proved increasingly undesirable and one of its strongest opponents was the late President Eliot. The elective system then became popular and while it broadened and enriched the curriculum, its tendency was to make education a means rather than an end. Its greatest concern was for the individual and so it was detrimental to the general social good. "In the third period of our higher education, have not our colleges and universities become more like glorified athletic clubs or country clubs or Chautauqua circuits or dance halls?" Physical and material things are stressed at the expense of spiritual and intellectual and the responsibility for this situation seems to be divided among students, parents, and faculty.

The great need today is for a new educational era wherein spiritual and mental values supersede the present material and physical values. The primary purpose of college should be to teach students how to live a rich full life in the best sense of living. An altruistic attitude should be cultivated and the importance of service should be dwelt upon. Coöperation would result from this method.

At college the social problems of the nation should be solved, such as transportation, distribution, taxation, congestion in cities, struggle of capital and labor, causes of war, prevention of disease, reform of legal procedure, etc. We would be a different nation were the colleges to attempt the solving of such vital problems. Ten suggestions are made for the improvement of the present system: (1) the elimination of students who are not at college for education in the truest sense; (2) intercollegiate athletics should be abolished or if this is not feasible, these activities should be curtailed, (3) social activities of all kinds should be restricted, (4) most organizations of the student body should be done away with, (5) the college curriculum should be changed and many courses having neither cultural nor disciplinary value should be stricken out and less election should be permitted. Research work should be confined to graduate schools, (6) the faculty should be carefully chosen and real leaders should be obtained, (7) the teacher should be a leader whose ideal is the discovery of truth and he should not impose his views but rather lead his students to think for themselves. College boards should have their power lessened for too often they are without academic training or social ideals, (8) the better type of students should get more attention than formerly has been their lot, (9) morals and even religion should be included in the curriculum. (10) Since the business of life is to live, all subjects should be taught with this end in view and the relation of each subject to life should be stressed.

If we were to have a new program of education based on these improvements not only would a new social order in the colleges result but the reform would soon become wide-spread and the ideal of universal brotherhood much nearer of attainment. K. S. H.

When Priestley Was a Teacher. H. G. GOOD. *Sch. and Soc.*, **24**, 313–9 (Sept. 11, 1926).—In 1773 Joseph Priestley, one of the pioneers of modern chemistry, began

his scientific career by winning the Copley medal because of his invention of soda water. In 1774 he made his great discovery of oxygen through the accident of a burning lens. Later he isolated hydrogen chloride and pointed out that its solution in water was hydrochloric acid.

At this time he was also deeply interested in theological study and it was Edward Gibbon who urged him to specialize exclusively in philosophical study and research. Throughout his life, Priestley was an investigator, teacher, discoverer, and reformer. Having been bred in English dissenting academies he became a teacher in one and there formulated and expressed views of education that greatly aided Herbert Spencer later on. Most teachers are tempted to win pupils to their views rather than teach independent thought. Priestley may have been guilty of doing this but we have much evidence that he wanted to teach the truth at all times. His own education had taught the viewing of all questions from all angles.

After finishing his school days he became pastor in a social congregation and earned 30 pounds annually. To help meet expenses he tried to establish a school but was unsuccessful due to his unorthodox ideas. He did get a class of ten to listen to scientific lectures but barely cleared expenses. Three years later in a new church he started a school and obtained 30 pupils. He used the money made in this connection for buying more apparatus to teach science. In 1761, at the age of 28, he accepted the chair of languages at Warrington Academy. This institution, without the tradition or beauty of the more orthodox schools, was making educational history and was the most outstanding institution of Presbyterian liberalism. At this time the old universities had degenerated into what were almost social clubs and it was then that Priestley made his famous protest to the prime minister.

Priestley was both a teacher and scientific investigator. As a teacher he always encouraged discussion and was an advocate of students early learning the use of scientific apparatus. In this, he was ahead of his time for not until the 1820's were laboratories introduced into schools. Even as a boy Priestley had taught others but his actual class-room work consisted of 3 years at Nantwich and 6 years at Warrington. In his later years he attempted to establish a college in northern Pennsylvania. He early became a writer on education and has several works to his credit in this field. Two of Priestley's ideas that are significant are: (*a*) education should be controlled privately, by individuals, not by the state, and (*b*) schools should teach what will be most useful to the student in the widest sense.

A perusal of Priestley's works and a comparison of them with the writings of Herbert Spencer will show how greatly modern education is indebted to Priestley. The great schools of business, of which Wharton School at the University of Pennsylvania was the pioneer, are but concrete illustrations of fitting a man for meeting the actual problems of life and it seems significant that it was the university founded by his great friend, Benjamin Franklin, that should have given his ideas concrete application. Because of political intolerance Priestley was forced to leave England and this distinguished scientist found peace and quiet in Northumberland, Pennsylvania, where he lies buried today. K. S. H.

Scientific Research and Service. H. R. H., THE PRINCE OF WALES. Supplement to *Nature*, **118,** 9–14 (Aug. 7, 1926).—Presidential address delivered to the British Association at Oxford on August 4th. H. K. M.

Views and Reviews. ANON. Supplement to *Nature*, **118,** 15–20 (Aug. 7, 1926).—Summaries of addresses of presidents of sections. H. K. M.

Biology and the Training of the Citizen. J. G. KERR. *Nature*, **118,** 229–33 (Aug. 14, 1926).—From the presidential address to Section D of the British Association delivered at Oxford August 6th. H. K. M.

Domestic Refrigeration. ANON. *Nature*, **118,** 234–6 (Aug. 14, 1926).—A short historical review. In the choice of refrigerating fluid there is a great diversity; for example, ammonia, sulfur dioxide, ethyl chloride, methyl chloride, and a mixture of ethyl chloride and methyl bromide. Sulfur dioxide is greatly favored for small plants because the working pressure is lower than is the case with ammonia machines. It is also unique among refrigerants in that in the liquid state it has the properties of a lubricant. The serious drawback of sulfur dioxide is its affinity for water. The high boiling point of ethyl chloride well adapts it for use in hot climates. A disadvantage is the necessity for using, as a lubricant, glycerine which is hygroscopic. The admixture of methyl bromide with ethyl chloride renders the mixture non-inflammable. The primary requirement in the case of the small plant is reliability. Certain manufacturers have produced compressor type machines which are designed so that they cannot receive any adjustment in the hands of the user beyond the turning off and on of a

water tap and switch, while others have based their designs on the assumption that, if motive power is entirely eliminated, skilled attention becomes unnecessary. Two of the latter type, known as absorption machines, are described. H. K. M.

Science in Antiquity. J. N. FRIEND. *Nature*, **118**, 236–8 (Aug. 14, 1926).—Substance of an address delivered at the Royal Institution on June 10th. Deals particularly with the balance and weighing, and the telling of time. H. K. M.

Microstructure of Mercury. W. ROSENHAIN AND A. J. MURPHY. *Nature*, **118**, 261 (Aug. 21, 1926).—Surfaces suitable for microscopic study have been prepared by allowing the metal to solidify in contact with glass, and such surfaces have been successfully etched by electrolysis in hydrochloric acid (sp. gr. 1.12 at 15°C.). It has also proved possible to polish the frozen specimens, but so far it has not been found possible to etch surfaces prepared in that way. Microphotograph (×100) is given. H. K. M.

Dwi-manganese in Native Platinum. O. ZVJAGINSTSEV. *Nature*, **118**, 262–3 (Aug. 21, 1926).—The platinum was treated chemically and the final products were investigated Röntgenographically. Dwi-manganese would have been easily detected if it were present in the native platinum in quantities pointed out by Dr. Noddak or even 10 or 100 times less than that. The Röntgenographs obtained prove with certainty the absence of dwi-manganese in native platinum in a quantity exceeding 0.0003 per cent. Druce and Heyrovsky seem to have chosen a more trustworthy way, assuming that dwi-manganese is associated with manganese and not with platinum. H. K. M.

The Birefringence of Crystalline Carbonates, Nitrates, and Sulfates. C. V. RAMON. *Nature*, **118**, 264–5 (Aug. 21, 1926).—The theory of W. L. Bragg to explain the birefringence exhibited by crystalline carbonates and nitrates is that in the carbonate and nitrate ions the oxygen atoms are situated in one plane around the central carbon or nitrogen atom, and that as the result of this arrangement and of the mutual influence of the electric doublets induced in the atoms by the field of the light waves, the refractivity of the group depends to a marked extent on the direction of the light vector. It was suggested that, as sulfates show a very weak birefringence, very probably the oxygen atoms are arranged tetrahedrally around the sulfur atoms in the sulfate-ion group thus making it optically isotropic. Ramon shows that the light scattered by dust-free nitric acid is found to be nearly unpolarized, indicating an extremely large anisotropy for the nitric acid molecule and for the nitrate ion. Concentrated sulfuric acid and its aqueous solutions, on the other hand, polarize the scattered light nearly completely, indicating that the sulfate ion is nearly isotropic optically. This makes a striking confirmation of Professor Bragg's views. H. K. M.

The Production of Single Crystals of Metals and Some of Their Properties. H. C. H. CARPENTER. *Nature*, **118**, 266–9 (Aug. 21, 1926).—An address to the Institute of Metals delivered on May 19th. A review of the field with special emphasis on the work of Miss Elam and Professor G. I. Taylor. H. K. M.

The Classification of Research Work. W. L. BALLS. *Nature*, **118**, 298–9 (Aug. 28, 1926).—It has often been found difficult to discriminate between the different classes of work carried on by research laboratories. The three essentials of any research, for the purpose of classification, are the method, the subject, and the aim. Accordingly, as the research worker is left free to pursue his own course in each of these respects, or in so far as he is restricted to a limited choice of their possibilities, so we obtain eight separate classes of research activities covering a very wide range. Let us indicate freedom by capitals and restrictions by small letters. Then we have (*a*) MAS. This class is indubitably pure research, as typified by that of the university. (*b*) MAs. It consists in purely scientific study of such material as possesses industrial importance and is undertaken to broaden the basis of knowledge upon which effort ultimately rests. A determination of the chromosome numbers in species of Gossypiym for the cotton industry will serve as an example. (*c*) MSa. As most of the work done on behalf of public health which has one definite aim, though it studies mosquitoes or abattoirs and uses statistics or string galvanometers. (*d*) Mas. The everyday research of most industrial laboratories. It aims to effect paying improvements in specified materials and processes. (*e*) ASm. The usableness of a new discovery is investigated such as Röntgen's rays or the emission of electrons from a hot wire. (*f*) Ams. Intelligent technical benevolence. It is obviously a temporary phase through which much research passes in the course of its development. (*g*) Sma. Most patented inventions deal with some particular way of achieving something; the invention itself may be applied to many different industries. (*h*) mas. Testing rooms, work-control laboratories. H. K. M.

External Capillary Action. W. GALLOWAY. *Nature*, **118**, 300–1 (Aug. 28, 1926).—

When a glass tube, 6.5 mm. in external diameter, 5 mm. in internal diameter, one end of which has been drawn out into the form of a cone 55 mm. long with a hair-like apex 0.1 mm. in diameter is filled with water containing 1 per cent of sodium hydroxide and held with its point downwards at an angle of 35° above the horizontal, a minute stream of water issues from its aperture, turns round underneath its lip and ascends to a distance of 33 mm. on its outer side in the form of a series of minute, disconnected, elongated globules which appear to encircle it. In flowing upwards these globules gradually lose their identity and finally coalesce to form a substantial drop at a point where the diameter of the cone is about 2 mm. After the drop has attained a weight of about 0.0113 g. it breaks away from the influence of the force which has been holding it and falls from its apex. With the tube described (and illustrated by photographs), a drop was formed in this manner every 2 min., 20 sec. for 12 consecutive hours in one trial. H. K. M.

The Earliest Human Knowledge of Copper. P. E. SPIELMANN. *Nature*, **118,** 411 (Sept. 18, 1926).—The first discovery of metals by man is usually described as having resulted from the association of the necessary materials in the construction of a primitive hearth on some chance occasion. It is known that the earliest dynastic peoples suddenly appeared in Egypt equipped with a written language and with a knowledge of the making of metals and of agriculture. Sir Flinders Petrie suggests the possibility of the earliest Egyptian immigrants having come from Caucasus along the rivers of the Ioro and Kura. Copper occurs wide-spread throughout the Caucasian area. So also does petroleum, especially in the area mentioned. When a petroleum spring or lake became ignited, as is known occasionally to have happened, there is the greatest likelihood of the adjacent copper being reduced by the high temperature of the reducing flame to the metal itself. This suggestion is supported by the fact that copper was in use very early in the history of the country that is now known as Irak; this is also a petroliferous region. H. K. M.

Power Alcohol and Other Petrol Substitutes. ANON. *Nature*, **118,** 416–8 (Sept. 18, 1926).—There are not many possible alternatives to petrol. There are, indeed, immense supplies of liquid fuel lying dormant in the oil shales that are so abundantly distributed over the earth, but until methods of extraction and purification that are both technically and economically successful are devised, we shall continue to look to other fossil fuel, coal or peat, to vegetable matter, and to water gas to supplement our present supplies. Benzol is an excellent motor-fuel, but its production is comparatively small and it is required for dyes and explosives. Acetone is the ideal liquid for mixing with other motor fuels, but at present is too costly, although its commercial production through the acetic acid made by fermenting cellulose may be achieved at an early date. Alcohol is of especial significance because the raw materials of its manufacture, cellulose and sugar, are renewed by Nature and also because its value as a motor-fuel has been proved beyond doubt. Hydrocarbon oils of low boiling point such as are produced by hydrogenating coal and peat, or by passing water gas over heated catalysts are among the most likely substitutes for petrol. The economic aspects of the question as concerns Great Britain are discussed. H. K. M.

Teacher Rating in the Secondary Schools. V. T. THAYER. *Educ. Adm. and Superv.*, **12,** No. 6, 361–78 (1926).—Teachers have been in the past and in a great majority of cases, still are, rated on the old method of "general impressions." The judgments of the supervisor were controlled either by outlines or specifications, unfair both to the supervisor and to the teacher. The method was subjective to the extreme. In order to substitute an objective and accurate appraisal of teaching success, various types of rating scales have been devised. In the practical applications of rating scales there has developed a tendency to abbreviate and even abandon numerical ratings. One method of rating teachers is the score card. Philadelphia uses such a card which calls for three main divisions—instruction, management and coöperation, and professional attitude. Rugg worked out a very complete "man-to-man" scale to be used by teachers for their self-improvement. A third type of teacher-rating plan is based on an objective study of teaching results. However, neither of the three have proved entirely satisfactory, for human nature is very complex. No one can determine the true cause for a pupil's achievement. Is a rating expedient as a basis for determining re-employment, salary increases, and promotion? Rating scales have failed to eliminate the "unfit" or even make much distinction as to relative merits of teachers as it was found that 96 per cent of 7113 teachers were rated superior, excellent, or good. Such a scale presupposes a definite standard of teaching and none exists. Each teacher is an "individual" in the truest meaning of the term. The method of "general impressions" may be best after all to secure the most effective measure of a teacher's

worth. These "impressions" should be based on intimate contacts with the teacher's performance through which his or her strength and weaknesses can more accurately be known. S. R. P.

What Is the Matter with Teaching? ARTHUR D. NEELES. *Okla. Teacher*, **46**, No. 9, 403–4 (1926).—Several interesting conclusions are made in answer to a question which has occupied a prominent place both in recent public thought and in educational circles. The conclusions are: Teaching should be a life-time job; other fields offer greater appeal; the public does not fully appreciate the value of the teacher; tenure of office is insecure; many teachers are too young; colleges are not preparing future teachers to really teach; failure to eliminate the pedagogically "unfit;" and failure of the parents to coöperate with the teacher. S. R. P.

The Ionization of Gases as a Type of Chemical Activation. S. C. LIND. *Science*, **64**, 1–6 (July 2, 1926).—Of the various types of activation the commonest and most useful, that of temperature influence is the most complex in point of theory. Of the simpler types, activation of gas molecules by ionization is peculiarly suitable for investigation provided a constant source of ionization producing a known number of ions can be had and if in addition the chemical action produced can also be measured. A convenient source of ionization is the alpha particle from Radon (radium emanation) in equilibrium with its decay products.

In the case of the reaction, oxygen to ozone, the number of alpha particles of known velocity can be determined from the amount of Radon, and the ozone formed measured by passing through potassium iodide solution. The length of path in oxygen is known and the number of ion pairs formed may be calculated from the ionization per length of path. The ratio of ozonation to ionization of oxygen is near unity. In the synthesis of water from $H_2 + O_2$, an average of 3.85 molecules of H_2O were formed by each ion pair generated in the gas mixture. Detailed data are given on the effect of size and shape of vessel, pressure, and proportion of reactants, also upon the radiation of the following with and without oxygen: CO, CH_4, C_2H_6, C_3H_8, C_4H_{10}, C_2N_2, C_2H_2.

As the ionization rate of alpha particles is independent of temperature, the ionic chemical reactions were mostly found to be independent also of temperature but, because of possible influences of a secondary nature, reactions were carried out at 25°. When oxygen was present oxidation always occurred. Hydrogenation in presence of H_2 was not exclusive but was accompanied by polymerization. A theory of the mechanism of the ionic-chemical reactions is given. G. H. W.

Science and Civilization. W. F. DURAND. *Science*, **64**, 167–73 (Aug. 20, 1926).—A community life (civilization) implies specialization and coöperation. Progress in civilization, conditioned upon the exercise of special skill or aptitude, implies a field for the exercise of such specialized human effort. This is, of course, the whole domain of Nature and must obviously require an acquaintanceship with Nature and her so-called laws (science).

"If, then, we ask of the relation between science and civilization, the question answers itself. If civilization is a result of our gradually improving utilization of Nature's products and energies through a more and more effective partnership with her, and if science is the organized body of our understandings and agreements with Nature, the two are seen as inseparable parts of one whole. There could be no civilization without science—and, given a body of science with rational beings, a civilization must result." G. H. W.

The Scope of Organic Chemistry. J. F. THORPE. *Science*, **64**, 211–41 (Sept. 3, 1926).—Phases discussed: Structure, The Electronic Theory, Strainless Systems, Biochemistry, Analytical, The Utilization of Forest Products, Petroleum, Dyestuffs and Intermediates, Publications. G. H. W.

New Glass Transmits Ultra-Violet Rays. F. M. LOCKE. *Glass Ind.*, **7**, 137 (June, 1926).—With an estimated cost only slightly higher than ordinary window glass, a new glass has been developed which will transmit, when formed into reasonably thin sheets, the health-giving ultra-violet portion of sunlight. Though made of inorganic materials, the new material is of radically different formula from the normal glass, being higher in alumina and lower in silica. Also, considerable quantities of fluorspar are included in the batch mixture. The material was originally developed for use as an electrical insulator, in spark plugs, etc. V. R. T.

Organic Glass—A New Plastic. ANON. *Chem. & Met. Eng.*, **33**, 273 (May, 1926).—An organic glass substitute, prepared by Austrian chemists and given the name of "Pollopas," is claimed to have very desirable properties. It is colorless, transparent, capable of taking a brilliant polish, and surpasses ordinary glass in its ability to transmit ultra-violet light. In tensile and crushing strength it is not markedly different

from commercial glasses, though it is somewhat lighter, and soft enough to be turned on a lathe. The material, which is not yet being made on a factory scale, is a condensation product of formaldehyde and urea (carbamide). V. R. T.

Antiknock Motor Fuels by Cracking Shale Oils. J. C. MORRELL AND GUSTAV EGLOFF. *Ind. Eng. Chem.*, **18**, 801–2 (Aug., 1926).—Oil distilled from "oil shale" is one of the logical supplements for the diminishing supply of crude petroleum. Small-scale treatment of shale oil by "cracking" has shown a yield of 50 per cent of gasoline. No cost data, however, are given. Analysis of the gasoline indicates that it has high antiknock value due to the large content of aromatic hydrocarbons. The United States possesses sufficient known oil shale to supply the distillate for 150 years at the present rate of consumption. V. R. THAYER

The Advance of Rayon. OTTO WILSON. *Ind. Eng. Chem.*, **18**, 829–31 (Aug., 1926). —Rayon, the synthetic fabric which has proven such a strong competitor for silk, is admitted to have a superiority over cotton, from which it may be made, in but one quality, that of luster. The worst defect of the fabric is its weakness when wet. Manufacturers are seeking improvements chiefly with this fault in mind. The fabric is made by four processes, each involving the solution of cellulose, obtained from cotton or wood pulp, to form a plastic mass which is forced through a die to form fine threads, the latter being coagulated by the action of a suitable liquid. Solvents used include alcohol and ether following nitration; copper-ammonium solution; caustic soda, followed by carbon disulfide; acetic anhydride. The textile estimates for 1926 indicate a production of rayon far ahead of that of silk, and not greatly smaller than that of linen and wool. V. R. T.

The Relation of Light to Life and Health. WESTON A. PRICE. *Ind. Eng. Chem.*, **18**, 679–85 (July, 1926).—Experimentation has proved that calcium, the mineral food most important for the prevention of degenerative diseases such as rickets, must be activated in the body by some source of radiant energy before it can function effectively. Sources mentioned include direct sunlight, when not obstructed by clouds, smoke, or ordinary glass; cod-liver oil, especially when the latter has been exposed to sunshine for a carefully regulated interval; animal fats, such as butter and seal blubber; and ultraviolet irradiation under skilled direction. Trials made with rats and rabbits showed that resistance to infections is strikingly dependent upon the amount of activated calcium in the body. Price emphasizes the serious menace to urban dwellers, especially children, when the radiant energy is shut off, due to indoor habits, and the screen of smoke and clouds which covers cities in winter. V. R. T.

Systems of Chemical Engineering Education. ANON. *Ind. Eng. Chem.*, **18**, 975–8 (Sept., 1926).—Chemical engineering as a distinct curricular branch is only about twenty-five years old. Three rather divergent systems of instruction have been developed, and most schools now model their courses on one of these. Reports of the Committee on Chemical Engineering Education of the American Institute of Chemical Engineers have summarized the essential features of each. The "University of Michigan Plan" consists of student operation of equipment on a semi-plant scale, installations being made in the laboratories by various manufacturers. The Massachusetts Institute of Technology, School of Chemical Engineering Practice, has established field stations in industrial centers, where graduate students preferably, or selected seniors from the Institute, study problems in plant control, development, and operation. The "coöperative plan," originating at the University of Cincinnati, involves class-room instruction alternated with actual paid employment of students in selected industries. The merits of the various systems are discussed. It is well agreed that suitable instruction in chemical engineering can be crowded into four years only with considerable difficulty. V. R. T.

Fifty Years of Glass-making. ALEXANDER SILVERMAN. *Ind. Eng. Chem.*, **18**, 896–9 (Sept., 1926).—Under the topical headings—window glass, plate glass, bottles, electric bulbs, lighting and table ware, optical glass, and chemical and cooking ware, the author sketches briefly the main points in the development of each, including the status of the art in ancient times. The point is emphasized that although "rule-of-thumb" methods have survived unusually long in glass-making practice, the more progressive manufacturers have now recognized the extreme importance of accurate physical and chemical control of materials, process, and equipment.

NOTE: The cited issue of *Ind. Eng. Chem.* actually comprises a brief but comprehensive review of the progress of the entire field of applied chemistry in the United States for the past fifty years, each article similar to the one abstracted. Subjects treated include metallurgy, water supply and sewage, rubber, explosives, soap, Portland cement, steel, photography, paper pulp, aluminum, silk, dyes and dyeing, wood

distillation, aromatic chemicals, insecticides and fungicides, tanning, petroleum, cottonseed, fertilizer, commercial gases, paint, medicines, ceramics, and artificial leather, together with a chronological table for the whole. V. R. T.

Chemistry Determines Amount of Ultra-Violet Rays. ANON. *Nation's Health*, **8**, 347 (May, 1926).—Report of a method described in *Chemistry and Industry*, by J. E. Moss and S. W. Knapp, for measuring the intensity of ultra-violet rays. Oxalic acid is decomposed by the rays, in the presence of uranyl acetate. A standard solution, after exposure to the source of the rays for a measured time, is titrated with potassium permanganate. The relative transmitting ability of various types of glass may be determined easily. V. R. T.

America's Pure Food Pioneer. A. PHILIP MCMAHON. *Good Housekeeping*, **83**, 92–3 (1926).—A double celebration occurred in New York City last June 30th; the eighty-second birthday of Dr. Harvey W. Wiley and the twentieth anniversary of the signing of America's Pure Food Act by President Theodore Roosevelt.

The reason for combining the two functions was that Doctor Wiley, more than any other person, was responsible for the final successful passage of the Pure Food Act. The outstanding features of the law are: honesty of labeling and freedom from injurious added substances. One speaker stated, "We are now face to face with an effort .. to destroy .... the honesty in branding feature of the law." In this he referred to the bills now pending in Congress permitting the substitution of starch (glucose) sugar for (cane) sugar without informing the consumer of the fact. B. C. H.

New York High School Groups Slow and Bright Pupils. ANON. *School*, **37**, 831 (Aug., 1926).—One of New York's newer high schools, James Madison, will classify its students into three divisions beginning with the fall semester of the school year 1926–1927. The groups will be: average, bright, and slow students. These different groups will be placed in entirely separate parts of the building, each group with a distinct Assistant Principal in charge. The slow students will be given special and intensive training in an effort to keep them abreast of the average group while the division of bright pupils will be schooled under a modified syllabus in order to provide adequate work for their abilities. B. C. H.

Golden Jubilee Number. *J. Am. Chem. Soc.*, **48**, No. 8A (August, 1926).—The committee for the historical program of the Semicentennial meeting of the A. C. S., of which Dr. Chas. E. Browne is chairman, have made, in the Golden Jubilee Number, a distinct contribution to the historical literature of American chemistry. To review adequately the entire issue of 254 pages in a brief abstract is not to be thought of. Only the barest outline is here given of a volume which should find a place in the library of every chemistry teacher.

The volume is entitled "A Half Century of Chemistry in America, 1876–1926." It is divided into two parts, preceded by an introduction by Dr. Browne. Part I is headed "Origins and Developments of the American Chemical Society," and comprises five chapters, as follows:

The Priestley Centennial.
The Organization of the American Chemical Society.
The Evolution of the American Chemical Society.
The First General Meeting and the First Local Section of the A. C. S.
The Activities of the American Chemical Society.

Part II is entitled "Reviews of Progress in Various Branches of Chemistry in America, 1876–1926." It comprises eight chapters, as follows: Mineral Chemistry, Physical Chemistry, Inorganic Chemistry, Organic Chemistry, The Chemistry of Physiology and Nutrition, Agricultural Chemistry, Industrial Chemistry, and Chemical Education. The eminent authors of these chapters have admirably summarized, in the limited space allotted to each, the progress in their respective fields in a highly interesting manner.

The volume contains 59 photographs. Particularly interesting is that of the group of chemists at the Joseph Priestley Centennial held at Northumberland, Pa., Aug. 1, 1874.

The volume is a worthy successor to that issued in 1901 and published as a journal supplement, commemorating the 25th anniversary of the Society. A. P. B.

A Method of Estimating Atomic Weights with the Aid of the Periodic Law. EDWARD W. WASHBURN. *J. Am. Chem. Soc.*, **48**, 2351–2 (Sept., 1926).—The relationship between atomic weight and atomic number proposed by Harkins and Wilson does not hold well for elements above nickel, perhaps because many of these elements are mixtures of isotopes. All elements whose atomic weights have not been determined fall in the last five rows of the periodic chart. A graphical method is presented which the

author believes can be used with considerable confidence for the estimation of most of the missing atomic weights. The ratio of the atomic weight of each element to that of the next preceding and next succeeding zero-group element is computed. The ratio of the corresponding atomic numbers is also obtained, and the difference between the two ratios is plotted against the atomic numbers. Nine curves are shown and the estimated atomic weights of the seven elements for which they have not been determined are computed from the curves. A. P. B.

Lecture Experiments with the New Halogenoid, Azido-Carbondisulfide. A. W. BROWNE AND R. S. VON HAZMBURG. *J. Am. Chem. Soc.*, **48**, 2383–5 (Sept., 1926).—The surprising reactivity of azido-carbondisulfide toward various groups of substances, including acids, alkalies, oxidizing and reducing agents, and its susceptibility to autocatalytic decomposition even at ordinary temperatures, render available a set of instructive experiments suitable for lecture-table use. A number of interesting experiments are given in detail by the authors, demonstrating the halogenoid character of the compound, its thermal decomposition, its sensitivity to mechanical impact, heat, and the chemical action of ammonia gas. A. P. B.

The Birth of Modern Science. JOHN K. ROBERTSON. *Sci. Mo.*, **23**, 138–51 (Aug., 1926).—R. defines the modern scientist as one who is more interested in a knowledge of the ultimate structure of gold than in its possession; who seeks not to build airplanes but to understand the laws of flight; who studies the starry heavens, not to cast horoscopes, but to learn something of the universe of which he is a part; who looks at the lilies of the field and wonders why they grow. He does not seek to evolve in his own mind the laws of the universe but collects all the facts he can about the problem he is investigating and experiments to find additional facts, then tries to correlate all these by a reasonable explanation, *i. e.*, he formulates a theory. He then proceeds to test the theory by further reasoning and experiment. "Experiment and see" is the scientist's answer to innumerable questions. The beginnings of science were so bound up with philosophy that little experimentation was done. Until Galileo dropped the two weights from the tower of Pisa no one seemed to think of testing the claims of Aristotle that bodies fall the faster the heavier they are. Not even in the sixteenth century was there any great outburst of what might be called modern science. There was progress but advances were slow, due to the fact that interest was in the glory of a past civilization as much as in the world about them; to the fact that experiment and observation are necessarily slow, especially since measuring instruments such as telescopes, microscopes, thermometers, and the pendulum were unknown; and to the fact that few men can rise entirely above the common prejudices of their day and generation. Galileo had to fight the prejudices of the Renaissance but in the year in which he died, Isaac Newton was born and during his life modern science came into full daylight. G. W. S.

Synthetic Rubber. H. E. HOWE. *Sci. Mo.*, **23**, 257–9 (Sept., 1926).—Rubber is a complex substance. The latex which comes from the rubber tree is a liquid, perhaps a colloidal solution of a mixture of three or four hydrocarbons with non-rubber substances, principally proteins. The exact duplication of such a system is unquestionably very difficult. During the war a material called synthetic rubber, suitable for making hard rubber materials only, was produced in Germany from acetone, but nothing is known of its yield or cost. Its production from isoprene, which may be obtained from turpentine, has not been successful because of low yields. Early workers discarded petroleum as a raw material, although coal tar was favored in Germany and starch in England. More recently petroleum has received the attention of American chemists and much work is being done along these lines. The Department of Commerce investigation showed that plantation rubber can be produced for thirty cents per pound, hence the chemist must not only overcome the great technical difficulties but must obtain his product at a low cost. As scientists develop new facts regarding crude rubber and more information is obtained concerning catalysts, atomic structure, and the relationships that exist between molecules, the prospect of synthetic rubber will grow nearer. G. W. S.

Plantation Rubber: Its Source and Acquisition. FRANCIS E. LLOYD. *Sci. Mo.*, **23**, 269–78 (Sept., 1926).—Of the many trees, shrubs, and herbs which produce rubber, only one, *Hevea Braziliensis*, has been found satisfactory. Seeds taken from the Amazon region in 1876 formed the beginning of the industry which now furnishes the world's rubber, 80 per cent of which comes from Malaya and Netherlands India. Normally the seeds, after falling from the tree, germinate at once and if prevented lose their vitality. This fact made their acquisition from Brazil difficult. The budding of good grade seedlings is now coming into use. Trees at the age of about 5 years

become "tappable." The product of the rubber tree, called latex, is derived from the bark only, and tapping requires an understanding of the structure of the bark or cortex, the total thickness of which is about 8 mm. in trees ten or more years old. The author describes methods of tapping and of preparing the latex for shipment. The latex is a milky fluid containing about 30 per cent rubber. A yield of 400 lbs. of rubber per acre per month is considered a good yield. A number of illustrations showing the trees and the rubber in its various states are given. G. W. S.

Foundation of Science Teaching. JOHN J. BIRCH. *Sch. and Soc.*, **24,** 267–8 (Aug. 28, 1926).—Due to much difference of opinion as to method and content in teaching science in high schools, this entire field is in a chaotic state. Now a student can cram and pass examinations but this seems undesirable. What is needed is a cultivation of a spirit of investigation and not blind acceptance of investigation by others. "Science should be taught in such a way as to become a real training of the student in the methods of science, with a view to the forming of the scientific mind." Project method and original work will greatly aid toward this end. K. S. H.

On the Rare Earths. ANON. *Nature,* **118,** 17–8 (July 3, 1926).—A short review with bibliography. H. K. M.

Oxidation, Passivity, and Corrosion. U. R. EVANS. *Nature,* **118,** 51–3 (July 10, 1926).—Based on two lectures delivered at the Royal Institution. A discussion of the various theories from results obtained by experiments on lead, copper, and iron. H. K. M.

The Chemical Constitution of Thyroxine. ANON. *Nature,* **118,** 65–6 (July 10, 1926).—The physiological properties are described in a review of Kendall's work. Our knowledge has been carried a step further by Harrington who has improved the method of extraction and has proceeded to determine its chemical constitution by methods of degradation and synthesis. At present synthesis has only been carried to the penultimate stage but there is every reason to hope that the complete synthesis will soon be successful. H. K. M.

Solidification of Helium. W. H. KEESOM. *Nature,* **118,** 81 (July 17, 1926).—Solid helium forms a homogeneous transparent mass, the refractive index of which probably differs extremely little from that of the liquid. At 4.2°K. helium solidifies at 140 atmos., at 3.2°K. at 86 atmos., at 2.2°K. at 50 atmos., and at 1.1°K. at 26 atmos. The solidificative curve bends so that at the lower temperatures it shows a tendency to become parallel to the temperative axis. Helium would then be expected not to have a solid-liquid-gas triple point. H. K. M.

High Order X-Ray Reflections from Fatty Acids. J. A. PRINS AND D. COSTER. *Nature,* **118,** 83–4 (July 17, 1926).—X-ray reflection from fatty acids shows the existence of a long spacing, which increases proportionally to the number of carbon atoms in the molecule. Using fatty acid crystals, the authors have succeeded in observing reflections up to a very high order. The work of Muller, Shearer, and others is confirmed and in addition a remarkable fact is revealed in the case of palmitic and lannic acids. The 34th order of palmitic acid appeared distinctly in four hours on the photographs whereas others higher than the 28th could not be detected even with exposures of 6 to 8 hours. In the same way the 26th order of lannic acid was clearly visible and no others higher than the 21st order could be detected. They conclude that the singularity depends on the fact that the scattering matter is not uniformly distributed along the chain of the molecule, but contains a periodicity due to the successive CH_2 groups. H. K. M.

Transmutation Experiments. M. W. GARRETT. *Nature,* **118,** 84 (July 17, 1926).—Negative results are obtained in attempting to change mercury into gold by the reported methods. Attempts to prepare indium from tin, and scandium from titanium have also failed. The experiments are described. H. K. M.

The New Element of Atomic Number 61: Illinium. B. BRAUNER. *Nature,* 118, 84–5 (July 17, 1926).—Concerning the existence of theoretical grounds for supposing that eka-neodymium might exist before Moseley's rule showed that element No. 61 was still to be identified. Brauner points out two cases. The difference between the atomic weights of Sm − Nd = 6.1 and is greater than that between any other two neighboring elements. It is of the same order as that between Mo − Ru = 5.7 between which stands eka-manganese and of Os − W = 6.9 between which stands dwi-manganese. Also, on arranging the time hydrides of the elements of the 8th series of the periodic system according to the order of their atomic weights, we find CsH, BaH_2, LaH_3, CH_4, PrH_3, NdH_2, $(XH_1)SmH_5$. There should be an element X and it is Illinium. H. K. M.

Organic-Metallic Compounds. W. N. GEORGE. *Nature,* **118,** 85 (July 17,

1926).—An X-ray investigation of the structure of the series of compounds C, Si, Se, Sn, and Pb tetraphenyls, now almost completed, appears to indicate an interesting field of research in the organic-metallic compounds. It is proposed to extend the work and make a systematic study of the effects of varying (1) the element, and (2) the groups. He wishes to borrow small quantities of any related organic-metallic compounds which may be solids in air at ordinary temperatures. Satisfactory results have been obtained from crystals 1.5 mm. by $(0.065 \text{ mm.})^2$, while from 0.15 g. of powdered tin tetraphenyl a number of suitable crystals were grown. H. K. M.

X-Rays and Living Matter. J. A. CROWTHER. *Nature*, **118**, 86–8 (July 17, 1926).—Substance of two lectures delivered at the Royal Institution. H. K. M.

The Imperfect Crystallization of Common Things. WM. BRAGG. *Nature*, **118**, 120–2 (July 24, 1926).—Abstract of lectures delivered at the Royal Institution. H. K. M.

Sir James Colquhoun Irvine. CHARLES D. HURD. *Chem. Bull.*, **13**, 200 (Sept., 1926).—The occasion of the sketch was the presentation of the Willard Gibbs medal to Sir James at Chicago early in September. This represents the third public appearance of Principal Irvine among American chemists. His first visit was to the dedication of the Sterling Chemical Laboratory at Yale in 1923. The next year he was at the Ithaca meeting of the A. C. S. He was among a number of prominent foreign chemists at Columbia University in July of this summer and was at Williamstown in August where he delivered a series of lectures on "Chemistry and World Progress" at the Institute of Politics.

Principal Irvine was born at Glasgow in 1877. His education included Allen Glen's school and Royal Technical College, both in Glasgow. His further training was at the Universities of St. Andrews and Leipsig. From the latter he received his Ph.D. He holds many honorary degrees; among them being D.Sc. from St. Andrews; LL.D. from Glasgow and Hon. D.Sc. from Liverpool. He has been a Fellow of the Royal Society since 1918 and is a Fellow and also Vice President of the Royal Society of Edinburgh. He is, at present, Principal and Vice-Chancellor of the University of St. Andrews and because of his administrative duties he claims that chemistry is only a recreation with him. Prior to 1921 he was professor of chemistry and Dean of the Faculty of Science. B. C. H.

Text vs. Laboratory. GERALD J. LEUCK. *Chem. Bull.*, **13**, 201–2 (Sept., 1926).—The author after some experience in the laboratories of Europe undertakes, in the article under abstract, to say that the chemists of the continent are in general better technicians than their American contemporaries; but, on the other hand, the Americans are more widely read than European chemists. B. C. H.

Duke University of Durham, North Carolina. ANON. *School*, **38**, 17–20 (1926).—An account of the origin of this institution, its evolution through an institute, an academy, a normal school to a college; its acquisition by the Methodist Church South; its removal to the city of Durham where it first began to attract the attention of the Duke family; and the ultimate receipt of the $40,000,000 endowment which now makes it the most heavily endowed university in America. An account of its ideals and plans for the future is given largely in the words of its president, William Preston Few. B. C. H.

The Dearth of Men Teachers. EDITORIAL. *School*, **37**, 820–1 (July 22, 1926).—New York City finds each year a decreasing number of men teachers in both high schools and grades. Fifteen years ago the system had 989 men teachers while there are only 701 at the present time.

In attempting to find reasons for this shortage a questionnaire was sent out. Answers received included the following as objections of men to teaching as a profession: Financial return is not comparable with that in the business world for the same type of service; "academic living is relatively sequestered, narrowing, and even offers less broad opportunities for vital service than does business or some other profession;" promotion, especially in a large system, is relatively slow; and finally the excessive demands made upon a high-school or grade teacher's time for making reports and attending to purely routine matters instead of real teaching.

It is suggested that if there must be such a burden of clerical work that clerks be employed for such service. "It is wrong to have employees who are paid to do creative work doing work that could be done by a clerk." B. C. H.

Local Activities and Opportunities

University of Georgia. Dr. H. C. White, head of the department of chemistry at the University of Georgia, is beginning his 55th consecutive year as professor of chemistry there. He is still entirely active and is teaching his full quota of classes.

Chemical Society of Washington. (Local Section, A. C. S.) The 381st meeting of the Society was held in Washington, D. C., October 14th. The program included the following addresses: "Tests with Attractants and Repellents for Flies," by R. C. Roark; "The Effect of Alkalinity of Basic Cupric Sulfates," by O. A. Nelson; and "The Influence of Colloids on the Rate of Solubility of White Arsenic," by C. M. Smith.

Lexington Section, A. C. S. The 113th meeting of the Lexington Section of the A. C. S. was held at the University of Kentucky on October 13th. At this meeting Councilor J. S. McHargue gave a report of the Council meeting held in Philadelphia. Brief reports of special phases of the Philadelphia meeting were made by Dr. R. N. Maxson, Dr. F. E. Tuttle, and Dr. G. Davis Buckner.

The new officers for the year are: V. F. Payne, President; J. S. Pierce, First Vice President; A. M. Peter, Second Vice President; R. N. Maxson, Councilor; and Charles Barkenbus, Secretary-Treasurer.

University of Wisconsin. New appointments as assistants in the department of chemistry at the University of Wisconsin include: N. W. Bolyard, M.S., (Oklahoma A. and M.); B. L. Browning, M.S., (Missouri); W. E. Caldwell, M.E. (Montana School of Mines); E. D. Coon, M.S., (University of North Dakota); H. Cramer, B.S., (Akron); R. G. Crosier, B.S., (Beloit); G. H. Damon, B.S., (Wisconsin); F. Diwoky, B.S., (Oregon Agricultural); D. P. Graham, B.S., (Washington); J. Hale, B.S., (Wisconsin); H. J. Heaney, B.A., (Ripon); M. L. Holt, B.A., (St. Olaf); R. J. Kepfer, B.A., (DePauw); H. Kline, B.A., (Wisconsin); E. T. Lessig, B.S., (Penn State); B. Landow, B.S., (Rochester); W. Madson, B.A., (St. Olaf); E. F. Ogg, B.A., (Carleton); J. H. Peterson, B.A., (St. Olaf); G. J. Pfeiffer, B.A., (Ripon); O. T. Quimby, B.S., (Montana).

Teachers' College. The sum of $20,000 presented to Professor and Mrs. Julius Sachs on the occasion of their golden wedding, has been established as an Endowment Fund at Teachers' College, Columbia University. The Fund is to be used for the purpose of promoting, by a series of prizes, the progress of secondary education in the United States.

For the year 1926–1927 the Sachs Endowment Fund offers a prize of one thousand dollars for the best essay or treatise on "The Aims and Methods of Science Teaching in the Successive Stages of a Secondary School, and the Intellectual Equipment of the Teacher That Will Enable Him to Put These Aims into Practice." All manuscripts must be in the hands of the Dean of Teachers' College, Columbia University, on or before December 1, 1926. The rules governing the competition for the science prize may be secured from the Secretary of Teachers' College, 525 West 120th Street, New York City.

University of Arizona. Dr. Burton E. Livingston, of Johns Hopkins University and permanent secretary of the American Association for the Advancement of Science, who is at present carrying on research at the Desert Laboratory of the Carnegie Institution, located in Tucson, delivered an interesting lecture before the Sigma Xi Club in the Chemistry Lecture

Room, September 18th. The subject of his address was "Plants and Water."

Dr. Ernest Anderson, chairman of the department of chemistry, was elected President of the Sigma Xi Club of the University of Arizona for the session 1926–27.

Professor Joel H. Hildebrand of the University of California, has accepted an invitation to deliver a series of lectures under the auspices of the department of chemistry during the first week in November, 1926. The titles of his addresses were: "The Constitution of Atoms;" "Atoms and Other Atoms;" "Molecules and Other Molecules;" and "Chemistry at Surfaces."

Dr. L. E. Roberts, associate professor of chemistry, was advanced to a full professorship at the close of the 1925–26 session.

O. E. Schupp, Jr., instructor in chemistry, attended the Philadelphia Meeting of the American Chemical Society as well as the conclave of Phi Lambda Upsilon. He is the President of Phi chapter which was established at the University of Arizona last February.

On Friday, September 24th, Dr. R. J. Leonard, assistant professor of geology, addressed the Arizona Section of the American Chemical Society. The title of his lecture was "The Hydrothermal Alteration of Certain Silicate Minerals."

Cincinnati Section, A. C. S. A joint meeting of the Cincinnati Section of the A. C. S. with the American Society for Steel Treating and the American Society of Mechanical Engineers was held on October 6th at the University of Cincinnati. The speaker of the evening was Dr. William M. Guertler whose subject was "Systematic Procedure in Establishing the Limits of the Utilization of New Metal Combinations in Technical Practice." The regional meeting of the Cincinnati section was held in Cincinnati on October 22nd–23rd.

College of the City of Detroit. Under the leadership of Prof. F. C. Irwin the chemistry department of the College of the City of Detroit is making rapid advances. Six hundred students are taking work in this department this semester which is a twenty per cent increase over last semester. The faculty which numbers twelve has lately added Mr. A. J. Campbell, formerly of Cass Technical High School (Detroit), to its list. The large increase in enrolment has necessitated the addition of a new analytical laboratory.

M. C. C. T. A. The executive committee of the Michigan College Chemistry Teachers' Association held a meeting at the Michigan State Normal College at Ypsilanti on October 9th. At that time details of the program for the coming winter meeting were arranged.

Langley Association of Science Teachers. At the annual meeting of the Langley Association of Science Teachers held at Pittsburgh, Pa., October 22nd–23rd, action was taken looking toward the formation of a more perfect union of the science teachers of the state. Leaders in the Pennsylvania State Education Association have long felt the need of an organized science section to meet in December of each year at which time representatives may gather from local branches with headquarters in the several convention districts of the state. The Langley Association has consented to assist in this important movement which will be started at the State Convention of the P. S. E. A. at Harrisburg, December 28th–30th.

The program of the October meeting included a tour through the Bureau of Mines, a reception in the auditorium of the Bureau of Mines, annual election of officers, and the following addresses: "The Recent Total Eclipse of the Sun" by Dr. Heber D. Curtis; "The First Day in Chemistry" by Charles A. Gorgas; "Carbon Monoxide Poisoning in the Home and on the Highway" by Dr. William P. Yant; and "Research at Low Temperatures" by Dr. C. W. Kanolt.

Anyone desiring to join this association or inquire concerning its publication *The*

Langley Science Bulletin should communicate with the secretary, Frank W. Murphy, Oliver High School, Pittsburgh, Pa.

Princeton University. Prof. L. W. Jones has returned from Europe where he spent about seven months visiting the chemical laboratories of many universities and institutes. Dr. Jones was traveling at the request of the International Educational Board.

Prof. H. S. Taylor delivered a lecture on "Catalysis" before the Maryland Section of the American Chemical Society, at Johns Hopkins University, October 29th. He has also accepted an invitation to address the Franklin Institute, Philadelphia, on December 2nd, his subject being "Atomic Hydrogen and the Mechanism of Catalysis."

Prof. William Foster addressed the New Jersey Science Teachers' Association in Atlantic City, November 12th. His subject was "From Atom to Life."

Prof. N. H. Furman, after teaching physical chemistry during the summer session of Stanford University, has resumed his duties at Princeton.

Mr. A. S. Richardson, '13, head of the research department of Procter and Gamble, Cincinnati, is engaged in research work at Princeton where he will remain until about January 1st.

Prof. C. L. Fleece, who has taken up his work as head of the department of chemistry of Central College, Mo., has received the degree of Doctor of Philosophy from Princeton University.

Dr. Erich von Gebauer Fülneg, assistant in chemistry, University of Vienna, is spending the year at Princeton as a fellow of the International Educational Board.

Prof. W. A. Noyes of the University of Illinois lectured before the Chemical Club, October 18th, on "Valence."

Dr. R. N. Pease, Ph.D. '21, associate professor of chemistry, University of Virginia, is conducting research on some of the chemical properties of hydrocarbons. The work is being done under a grant from the American Petroleum Institute.

University of Florida. Construction on the new Chemistry-Pharmacy building has been begun, and the first unit is expected to be completed by June, 1927.

Prof. A. P. Black and Curator B. O. Otte have made a ten-day trip to Chicago and adjacent points to study the manufacture of laboratory furniture in the factory.

Johns Hopkins University. On October 22nd and 23rd the Johns Hopkins University celebrated its fiftieth anniversary. The first general meeting marked the opening of the new million-dollar building of the School of Hygiene and Public Health, with an address by Dr. Andrew Balfour on "Hygiene as a World Force." Dr. Balfour is Director of the London School of Hygiene and Tropical Medicine. On the second day the principal address was delivered by Professor L. Lévy-Bruhl, of the Sorbonne, on the subject, "Research as It Is To-day." An event of particular interest to chemists was the presentation to the University of a portrait of Ira Remsen, painted by his son Ira Remsen, Jr. Dr. Remsen was present at the celebration and contributed greatly to the pleasure of his former students who had returned for the occasion.

The Departmental Conference in Chemistry was addressed by Professor E. C. Franklin of Leland Stanford. He discussed principally the organic chemistry of the ammonia system, giving numerous demonstrations.

University of Chicago. On Thursday evenings, beginning October 7th, a series of four chemistry radio lectures were broadcast from Station WMAQ by members of the University of Chicago staff. The lecturers and their subjects were: First, Professor Schlesinger, "Chemistry in the Service of Peace;" second, Professor Harkins, "The Transformation of Elements, Its Possibilities and Its Limitations;" third, Professor Stieglitz, "Chemistry and Health;" fourth, Dr. W. Lee Lewis, Director of Research, The Institute of American Meat Packers of

the University of Chicago, on "The Industries of the Chicago District."

On December 10th and 17th Professor Stieglitz will lecture in Fullerton Hall in the series, "The Nature of the World and of Man."

Among Kent graduates and former students who have accepted positions recently are Dr. Hoylande D. Young, '26, Research Chemist with Van Schaack Brothers' Chemical Works; Dr. T. W. Ray, '25, Instructor of Chemistry at University of Toledo; Dr. Gladys Leavell, Instructor of Chemistry at the Margaret Morrison Carnegie College, Pittsburgh; Drs. Francis R. Jenkins, '25 and N. A. Milas, '26, National Research Fellows at Harvard and Princeton, respectively; Rachel Brown on the Staff of the Department of Public Health, Albany; D. E. Wobbe, Ph.D., '26, Instructor at State Teachers' College of New Mexico; M. G. Frank, Ph.D., '23, Research Chemist with the Beechnut Packing Company; Paul L. K. Gross, Ph.D., '26, Instructor of Chemistry at Pomona College, California; L. F. Bate, Ph.D., '26, Instructor at Lincoln University; John Xanthopoulos, Ph.D., '26, Instructor at Ottawa College, Kansas; Verne D. Snyder, Research Chemist with R. R. Donnelly and Sons; Webster B. Kay, Research Chemist with the Standard Oil Company of Indiana.

Professor Broensted, University of Copenhagen, will give two public lectures at the University of Chicago, in February, on special topics of physical chemistry of interest to physicists, chemists, and biologists. The members of the American Chemical Society will be welcome at these lectures.

Neota Chemto. The chemistry teachers of Northeastern Ohio held a luncheon on Friday, October 29th, at which time Mr. John D. Morron, of the Mechanical Rubber Company, and Chairman of the Cleveland Section of the A. C. S., was the principal speaker. Following the luncheon, the Physics-Chemistry Section meeting of the Northeastern Ohio Teachers' Association was held in the Physics Auditorium of the Case School of Applied Science. At this meeting Dr. D. C. Miller, of Case School, gave an interesting explanation of some of his ether experiments.

On Saturday, December 4th, the members of the Neota Chemto will meet at Lorain for an all-day meeting. The morning is to be left open for discussions of teaching problems. Following luncheon, Dr. H. N. Holmes of Oberlin College will tell of his experiences and work in Europe during the past year.

Georgetown University. The Eastern States Division of The American Association of Jesuit Scientists held its fifth annual meeting at Georgetown University, Washington, D. C., August 12 and 13, 1926.

At the General Session the delegates were warmly welcomed by Rev. Charles W. Lyons, S. J., President of Georgetown University. The Rev. George F. Strohaver, President of the Association, then delivered his presidential address in which he very interestingly discussed Anomalous Valences. On the afternoon of August 12th and during the morning and afternoon of August 13th, sectional meetings were held in the lecture halls of the respective departments. The following program was carried out at the Chemistry Section Meeting:

Vice-presidential Address—Rev. Arthur J. Hohman, S. J., "Student Chapters of the American Chemical Society."

"The Research Institute of Georgetown University"—Rev. G. L. Coyle, S. J.

"The Evolution of the Chemical Elements"—Rev. Michael J. Ahern, S. J.

"Vitamin E, the Reproductive Vitamin"—Rev. George J. Shiple, S. J.

"Written Tests and Examinations"—Rev. Thomas P. Butler, S. J.

"Chemistry in the A.B. Course"—Rev. T. Joseph Brown, S. J.

"The Present Status of Nutritional Chemistry"—Mr. Francis W. Power, S. J.

"Chemistry Clubs"—Rev. Henry B. McCullough, S. J.

"Chemistry and Bacteriology"—Mr. Vincent A. Gookin, S. J.

"New Ideas on Laboratory Work"—Mr. Henry C. McLeod, S. J.

On September 15th, Georgetown University acted as host at a luncheon held at the College for the delegates to the Seventh Annual Conference of the International Union of Pure and Applied Chemistry. There were fifty-three foreign delegates listed, representing Belgium, Canada, Chile, Denmark, Esthonia, France, Great Britain, Italy, Japan, Netherlands, Poland, Roumania, Spain, and Switzerland. The United States was represented by fifty-seven delegates.

Dr. Vincent A. Gookin, S. J., professor of inorganic chemistry and moderator of the Chemistry Club has departed from Georgetown and has entered Woodstock College, where he will continue his studies. His place has been filled by Mr. L. C. Gorman, S. J., who comes to Georgetown from Woodstock College.

The staff has been augmented by the addition of another instructor in the person of Mr. John Sheahan, who comes to us from Holy Cross College, Worcester, Mass. Messrs. P. Francis Wilson, Arthur A. Espenscheid, and John Sheahan of the department are working for their Master's degrees. Their problems are in the field of qualitative analysis.

Industries Coöperate in Government Research. Sixty-one research scientists, representing 36 organizations most of which are national in scope, are at work at the U. S. Bureau of Standards, helping to solve industrial problems.

The purpose of this coöperation, according to Dr. George K. Burgess, director of that bureau, is to make well-equipped laboratories available for the mutual benefit of government and governed, to bind the bureau and industry more closely together, to encourage the application of science to industry, and to add government prestige to research results.

This is a further development of the purpose for which the Bureau of Standards was created by Congress, Dr. Burgess said. Coöperation between industry and government research is also fostered by staff meetings, conventions, and national and international society meetings.

As the direct result of this closer union of science and industry, more than $150,000,000 have been saved in the automotive industry alone, in brake linings, tires, and motor fuels. The steel industry is studying methods of treating and working iron and steel with gratifying results. The hosiery industry is one of those which maintains an associate research worker at the Bureau of Standards, with a saving already of 28 millions.—*Science Service*

Tissue Destruction Increases Blood's Germ Destroying Power. Destroying the tissues of the body apparently gives the blood additional power to destroy germs. Experiments undertaken by Dr. G. R. McCowen, surgeon commander of the Royal Navy, show that the inhalation of mustard war gas increases this quality in the blood. Other tissue-destroying substances such as hydrochloric acid and formic acid produce the same effect, he declares in a report to the medical periodical *Lancet*. No change in the effect of the blood on bacteria is noticed when substances are injected which do not produce a destruction of the body tissues.

It is suggested that this germ-killing capacity is due to an antibactericidal element from the white blood cells, whose traditional function is the defense of the body against disease, being turned loose in the blood when they are destroyed during the general disintegration of tissues.—*Science Service*

Recent Books

Curs Metodic de Chimie si Mineralogie. C. I. ISTRATI, Professor de Chimia Organica la Universitatea din Bucuresti, si G. G. Longinescu, profesor de Chimie Neorganica la Universitatea din Bucuresti. (14 × 20 cm.), 477 pp., 235 figs., and 20 portraits, 10th edition, 1926, Bucarest, Editura "Cartea Romaneasca."

The 10th edition of this book, just issued, follows close on the steps of its predecessor. It is a classical treatise in Roumania and was twice translated into French before the war.

The section dealing with organic chemistry has been completely rewritten, bringing it up to date with respect to the most recent advances and putting it in accordance with the new programs of teaching in Roumania. The plan and method have remained the same; the method is inductive and experimental. The setting up of 328 experiments is indicated, chosen among the easiest and most instructive and requiring only a very limited apparatus.

When it has been considered that the knowledge already gained by the students permits, and it is felt necessary, general theories have been developed, as well as problems particularly interesting from the industrial point of view, especially to the Roumanian students. Physical and natural phenomena are also explained. Thus the authors have expounded or described: the fundamental chemical laws, the atomic theories, thermochemistry, crystallographic systems, the petroleum industry, the great chemical industries of Roumania, the part played by physics and chemistry in the development of other sciences, etc.

Naturally, in the restricted space of a book intended for teaching and embracing the whole of chemistry and mineralogy, the authors could not but deal with a small number of elements, compounds, facts and industrial applications, but the selection and treatment of the theories has been made with such care that the students are enabled to acquire a very accurate general notion of chemical phenomena and to understand their importance and generality.

It is one of the great merits of such a book to implant and inspire a real and sincere interest in chemistry, instead of being, as books used to be in times not so far off, a mere collection of prescriptions and "a catechism to be learned by heart." This is best illustrated in the pages devoted to the organic chemistry.

The chief aim of the authors all through their work has been that which is the aim of any enlightened teaching, namely, to foster the scientific spirit.

The last pages of the book are occupied by considerations on the circulation and transformation of matter on the earth or in the universe, and what constitutes a characteristic of it, biographical notes on the great chemists and their work: Bayer, Ballard, Berthelot, Berzelius, Bunsen, Chevreul, Dalton, Davy, Dumas, Fischer, Friedel, Gay-Lussac, Hofman, Kekulé, Lavoisier, "the Reformer of the Chemistry," Liebig, Mendeleéff, Moissan, Pasteur, Ramsay, Saint Claire Deville, Schutzenberger, Wöhler, Wurtz.

The new edition, like its forerunners, is dedicated to the memory of one of the authors, Istrati, who died in 1918, and who was not only a great chemist, pupil of Friedel, Moissan, and Henry, but also played a conspicuous part in the politics of his country. A biographical note on him is signed by his collaborator, Prof. G. G. Longinescu of the University of Bucharest.

EUGÈNE LEMAIRE

A First Book in Chemistry. ROBERT H. BRADBURY, A.M., Ph.D., Head of Department of Science, South Philadelphia

High School. D. Appleton and Company, New York, 1922. xxii + 687 pages, 300 illustrations. 19 × 13 cm. $1.80.

The purpose of the book as stated by the author in the preface is to "obtain clearness of statement and simplicity of presentation and to interest the student while, at the same time, providing the opportunity to obtain information of permanent value. The industrial side of chemistry and its practical applications in the home are treated with unusual fullness. . . I trust that this book may aid the teacher in his difficult but pleasant task of gratifying the curiosity of the many students who desire to know not only what chemistry is, but what it has done for mankind."

The author has concentrated on this task all the accumulated experience of his successful career as a teacher of elementary chemistry. He has succeeded splendidly in his undertaking. He has presented the fundamentals of chemistry in a clear and convincing style, avoiding technicalities in the interest of his young readers. The material selected covers the field, but without the bulk so evident in some recent elementary texts. The illustrations are numerous, but well presented, wisely selected, and educationally valuable.

In the main the order follows the conventional development of the subject, but there are certain departures which attract attention. The introductory chapter gives a brief outline of the metric system, the centigrade scale and facts concerning density. After a brief chapter on physical and chemical changes, the student is introduced to oxygen through the medium of its effect on hot metals. Chemical symbols are explained on page 20 but their use is not introduced until page 162. Valence and nomenclature are missing from the first half of the book. Chlorine is described early, but the other halogens are not discussed until after most of the metals have been presented. The closing chapters deal with organic chemistry, explosives, war gases, foods, radium, and atomic structure.

Each chapter is followed by a summary and a list of exercises which are practical and thought provoking. An occasional group of review questions will fix permanently in mind the principles developed in preceding chapters. The appendix contains useful tables, logarithms, temperatures, atomic weights, physical constants and solubilities. The teacher who is anxious to keep his course of study abreast of the best in chemical education will also appreciate an accompanying pamphlet which shows in parallel columns how this text complies fully with the requirements of the course outlined by the Committee on Chemical Education of the American Chemical Society. B. S. HOPKINS

Organic Chemistry for the Laboratory. W. A. NOYES, Ph.D., Director of the Chemical Laboratory, University of Illinois. 5th ed., The Chemical Publishing Co., Easton, Pa., 1926. xiii + 329 pp., 45 figures, 23 × 15 cm. $4.00.

This is an improved edition of a well-known and long-used laboratory manual covering organic preparations. About 130 typical preparations are given. These are arranged in groups, one chapter to each group, hydrocarbons, 15; alcohols and phenols, 9; ethers, 3; aldehydes, ketones, etc., 13; acids, 14; acid derivations, 15; hydroxy- and keto-acids, 8; carbohydrates, 7; halogen compounds, 9; nitro, 7; amines, 17; diazo, etc., 8; sulfur, 4. As in the college text by the same author, aliphatic and aromatic compounds are studied together. Each chapter opens with a general review of the methods of preparation and of the properties of the class of compounds considered. The directions for the preparation of each compound are preceded by well-chosen references to the literature, not thrown together as is usually the case, but the contents and bearing of each reference are indicated. The first two chapters are on methods of analysis and general operations and the last is on the qualitative examination of carbon compounds.

The book is excellent for college students in organic preparations and should also be of service to graduate students. The compounds chosen cover a wide range of classes and of methods. The directions are accurate and clear and represent modern methods.

E. EMMET REID

Physics. M. H. KESSLER, B.S. Globe Book Company, New York, 1921. v + 103 + xvii pp., 83 figures, 15 × 22.5 cm. $0.67.

The author has compiled a manual to be used in preparation for examinations. Seven points have been emphasized: First, laws, principles, and definitions; second, typical problems; third, important diagrams; fourth, college examination questions; fifth, outlines of important experiments; sixth, an appendix containing important formulas with more college questions and answers; seventh, metric equivalents and important physical constants. The book is prepared for "two distinct purposes." First, "as a companion book to a standard text," second, "as a review before examinations."

There are eighteen chapters in the outline: Introduction; molecular motion; mechanics of liquids; mechanics of gases; motion and acceleration; force and equilibrium; gravitation and gravity-pendulum; work and energy; machines; heat; sound; light; magnetism; static electricity; current electricity; Ohm's law and its applications; effect of electric current; induced currents and their applications.

Each topic in the Review is in bold type, followed by a brief explanation. A series of related problems are added at the end of each chapter. Each type of problem is clearly explained and at least one example of each type is solved in detail. Answers to all numerical problems appear in the back of the book.

The text fulfils satisfactorily the two purposes for which it is written. It is a type of book which should be in great demand by tutoring schools and in college preparatory courses. It is in no measure a text-book.

LESLIE O. JOHNSON

Globe Laboratory Sheets. WILLARD B. NELSON. Globe Book Company, New York, 1926. vi + 44 pp., reference tables, 10 figures. 19 × 26.5 cm. $0.67.

Mr. Nelson has combined a set of laboratory report sheets in a bound manual. It is prefaced by a title page to be filled in by the pupil and a certificate to be completed by the instructor.

The student is given a short set of concise directions on the use of the book. Excellent sample diagrams for each laboratory science follow the preface. The actual working sheets are preceded by two pages for indexing 40 experiments.

The book is arranged so that two pages are available for each experiment. Lines are ruled as an aid to neatness. The left-hand page contains four topics in addition to the heading: Object of Experiment; Apparatus and Materials; Procedure; Observations. The last two items are arranged so that the observations may be made opposite the points in the procedure.

The top third of the right-hand page is blank for diagrams, the middle third is for computations, and the lower third is lined for conclusions and observations.

A series of tables is given including formulas; conversion tables; physical constants; chemical elements with their symbols, valences, and atomic weights; and a solubility table. Four pages of graph paper complete the manual.

The book is valuable for teachers who demand a "form" report. The paper is of fair quality, taking the ink easily.

LESLIE O. JOHNSON

Chemistry in the World's Work. HARRISON E. HOWE. D. Van Nostrand Co., New York, 1926. vii + 244 pp. 14.5 × 21 cm. $3.00, net.

As stated in the preface, "the object of this work is to emphasize in language easily understood by those not technically trained, the part which chemistry has

played in assisting in the attainment of our present level of civilization." It is the opinion of the reviewer that the author has admirably succeeded not only in showing how chemistry has developed so that it touches every phase of our life but also in telling the story in non-technical language and in a very interesting manner. The book is divided into sixteen chapters headed as follows: Solitude; Mental Isolation; Allies of the Sun; Food and Famine; Contributions of Chemistry to Cloth and Clothing; Decoration—Escape from Monotony; Metals, the Master; Materials of Construction; Permanency of Possessions; Health and Sanitation; Power; Abolition of Drudgery; Chemistry in National Defence; Chemistry, a Tool; Analysis and Synthesis; The Trend and Purpose of Modern Research.

In the first three chapters the reader is told how isolation, both mental and physical, has been banished and of the part chemistry has had in its accomplishment. Chapters four to thirteen, inclusive, show how chemistry has touched the various phases of our lives to give us the security and leisure we now possess, while the last three chapters give an indication of how the chemist works.

While the evident aim of the book has not been to discuss the chemistry of the different processes but to show the part played by chemistry, the descriptions, however, are clear and give a good general idea of the chemistry involved. Many subjects are touched upon and many descriptions are included though very little detail is given concerning methods. A considerable number of full-page illustrations showing modern chemical processes is interspersed through the text.

GEO. W. SEARS

Applied Colloid Chemistry. WILDER D. BANCROFT. McGraw-Hill Company, New York, 1926. Second edition. ix + 489 pages. 13 figures. 14 × 19 cm. $4.00.

The first edition of Professor Bancroft's useful book appeared in 1921 and promptly made a place for itself. The new edition is still better although there are no radical changes in treatment. The original 345 pages have increased to 489 of the same kind.

It must be admitted that this is not a text for beginners but rather a stimulating reference book for people who already know a good deal of colloid chemistry. The author is gifted in his ability to quote the vital statements from research papers and to offer keen comments on the same.

The chemist who is looking for a research problem or for additional light on a problem finds this book a gold mine. One may not agree with all the sparkling ideas tossed off so easily by Professor Bancroft but an hour with the book is certain to stimulate the flow of one's own ideas. We need such books.

The author himself regrets that his chapter on Non-aqueous Colloidal Solutions is so short. There has been too little research in that field. The treatment of the Electrical Properties of Colloids has been considerably expanded and there is more about Stability and other topics.

On page 18 a reference to Williams' paper, *J. Soc. Chem. Ind.*, **43**, 97T (1924), would have been helpful. Williams studied the separation of vapors by silica gel. On page 18 again it might be stated that Holmes and Anderson removed iron oxide *after* first drying the iron oxide-silica gel to a more or less rigid condition. This precaution prevents collapse of capillary walls. On pages 18 and 45 Reyerson's clever method of metallizing silica gels might be mentioned, *J. Am. Chem. Soc.*, **47**, 610 (1925). On page 196 "aluminum" should be "alundum." The discussion, on page 164, of Perrin's colloid atmosphere is admirably sane.

In short this is a book that every colloid chemist must have.

HARRY N. HOLMES

THE COMING OF THE HOLIDAYS

WITH the hurry and bustle of getting school underway, time has passed more rapidly than we realized.

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A magazine can best serve its readers when it makes every possible use of the constructive suggestions which are sent to it. Fortunately the readers of the *Journal of Chemical Education* have always taken a very active interest in the editorial make-up and advertising copy of our JOURNAL. Many valuable suggestions regarding both subject and advertising matter have come to us. These have been embodied in changes so that we all are profiting by this constructive thinking.

We want every reader to feel free to write us about any phase of the *Journal of Chemical Education*. It is your JOURNAL and it is our job to make it best fit the aims and ideals for which it was instituted. Tell us of authors, pictures, advertisers, new departments, in fact, of anything which in any way will make the *Journal of Chemical Education* better serve its purpose.

Please send along any suggestions. They will be welcomed.